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PROGRESS OF STANDARD DESIGN FOR ENTERPRISE ASU IN SECTOR

Moscow MEKHANIZATSIYA I AVTOMATIZATSIYA PROIZVODSTVA in Russian No 3, 1978, pp 26-29

[Article by engineer Kh. G. Gamzatov , candidate of economic sciences V. A. Pilipenko, and candidate of physicomathematical sciences A. I. Saksonov: "Setting up ASU's for Enterprises of the Machine Tool Building Sector on the Basis of Design Methods and Third Generation Computers"]

[Text] Work has gone forward during the Tenth Five-Year Plan to develop and improve ASUP's [enterprise automated control systems]. The USSR Ministry of the Machine Tool and Tool Building Industry has also been involved in this work. In conformity with the assignments of the Coordination Plan of the State Committee for Science and Technology of the USSR Council of Ministers and the annual national economic plans automated control systems have been set up at 34 enterprises of the sector; at 27 of them the first stage of the ASUP has been introduced, and at seven the design has been introduced.

Group computing centers have been set up and are serving groups of territorially close enterprises in Khar'kov, Vil'nyus, Vitebsk, and Voronezh.

The common ASUP hardware during the Ninth Five-Year Plan was second generation computers. The limited capabilities of these machines with respect to the structures of data in external memory to be processed were an obstacle in automating a number of functions of organizational and economic control of the enterprise, above all the functions of operational control of production.

The qualitative improvement in ASUP's being developed lags significantly behind their quantitative growth. At many of the ASUP's that were

introduced the range of problems did not form a complete cycle for automated production control, and this made such systems ineffective. Information bases were not organized on time at enterprises where ASU's [automated control systems] were being introduced. The data fed into the systems were not sufficiently complete and genuine.

The problems during introduction of ASUP's essentially reflected objectively existing contradictions between the needs of the functional part and the capabilities of the support part. A constant effort to resolve this contradiction has characterized the development and refinement of ASUP's throughout the entire 15-year history of automating organizational and economic control in our country.

During the 1970's the automation of more and more enterprise control functions demanded that the ASUP include procedures for operationally receiving complete and reliable secondary analytic accounting data to use to anticipate the course of production and regulation of it, to extract reference information in real time according to queries received, to shape optimal or close to optimal production programs for the enterprise and its shops by using mathematical economic methods, to optimize calendar productions schedules, and so on. However, the hardware of the ASUP, features of the construction of its information part, and the comparatively poor supply of system software greatly limited the possibilities of accomplishing these procedures.

The situation began to change with the practical introduction of third generation computers. By the end of the five-year plan the first ASUP's based on YeS [Unified System] computers had been introduced at enterprises in the country and series production of the computers was underway in the CEMA countries.

The first ASU based on YeS computers within the system of the USSR Ministry of the Machine Tool and Tool Building Industry was introduced in 1975 at the Odessa Press and Automatic Device Plant.

During the current five-year plan the YeS models being produced and the improved modifications of these machines already adopted by state commissions will become the common foundation of ASUP hardware complexes.

Two factors above all make third generation computers efficient to use in ASUP's. For one, the YeS computers are equipped with disc storage, an external memory with direct access that offers broad opportunities for organizing information arrays in the ASUP. Then, the Uniform System has well-developed software, a set of basic operational systems, packages of applied general-purpose programs, and complexes of technical servicing programs. This software guarantees a convenient level of interaction with the machine for the user.

The operational systems of the YeS machine are well in line with the capabilities of the external storage. The YeS disc operations system, which the junior YeS models (YeS-1020 and YeS-1022) are equipped with,and

the more powerful operations system that is delivered with senior models of the machines, insure the creation and processing of information arrays with different types of organization. In addition to the diversity of methods of organizing arrays that differ in access time, required memory capacity, and other parameters, the use of YeS computers greatly enriches the class of data structures used in the ASUP. The existence of external devices with random data sampling in particular makes it possible to store, in addition to the data elements, the linkages among them in the form of chains of address references from one element to another. This makes it possible to design and use heirarchichal data structures of varying degrees of complexity in the ASUP.

The systems of YeS computers have translators from languages of various levels and orientations. Along with the ASSEMBLER language which permits maximum use of the technical capabilities of the machinery, the input languages PL/1, COBOL, and RPG are oriented to use in the ASUP.

Significantly,incorporation of the YeS computers enabled ASUP designers to study and use the considerable experience accumulated throughout the world in setting up and operating electronic data processing systems.

Thus, the use of third generation computers presented significant additional opportunities for raising the level of design and the efficiency of performance of the computational and information-logical processes carried out in the ASUP.

Two primary aspects should be singled out in the new conception of the ASUP: (1) full integration of the ASUP information base and, as a result, organizational and technological separation of data feeding to the system from its processing by the meaningful function (so-called problem) programs in order to obtain results usable by the control apparatus; (2) construction of programs for standard functions of organizational and economic enterprise management in the form of packages of applied programs provided with sufficiently flexible means to match up with the conditions of specific enterprises.

The principal objectives pursued by the transition to the new design methods are the following:

1. Integration of information support makes it possible to form a reliable basis upon which the control functions being automated can be constructed without redesigning functions introduced earlier; in other words, the goal is to create favorable conditions for development and refinement of the ASU at the enterprise;

2. Integration of information support and its accompanying factors to minimize the redundancy of the data stored makes it possible to raise the reliability and timeliness of the data circulating in the ASUP, thus creating conditions for improving intraplant planning, in particular for optimizing it on the basis of mathematical economic modeling;

3. Designing problem packages of applied programs with a broad range of application that form a single system reconciled with the standard ASUP information base; this will make it possible, ultimately, to solve the problem of standardizing ASUP's in the sector, or at least on the scale of the machine building enterprises of the Ministry of the Machine Tool and Tool Building Industry for a start.

At the present time a transition is being made in the ASUP's to full integration of information support, setting up what are known as "data banks" within the framework of the ASUP. The chief function of the banks is to organize and maintain a dynamic information model of the enterprise as the object of control and to insure efficient access for users to the information being stored. The necessity of such an approach to information support was apparent earlier too, but it was made possible by switching ASUP's to third generation computers.

At the present time there are already, both abroad and in the USSR, developed information systems of the data bank type oriented to third generation computers which can be used in the ASUP either directly or as the prototype of a new developmental design.

Reorientation of the ASUP to third generation computers also stimulated a new approach to the problem of standardization of the ASUP. Standardization of the indexes included in the data base of the ASUP and their organization into arrays marks a significant step forward toward standardization of the entire machine part of the system. Thanks to the sophisticated means included in the ASUP data bank for performing the reference function the user is able to refer to the data bank to extract the information stored in the system that interests him. In this way, some of the information needs of the enterprise control apparatus are met only by means of the data bank.

The use of data bank-type information systems in the ASUP makes it possible to take a new approach to developing software for the standard functions of enterprise control.

Instead of a set of standard design concepts that are poorly reconciled with one another informationally and functionally, are figured for an unchanging data structure, and operate by rigid calculation algorithms, it is suggested that a system of packages of applied programs that interact with the ASUP data bank and perform the functions of the basic ASUP subsystems be set up. These functions are: control of technical preparations for production; technical-economic planning; operational control of production; control of material-technical supplies; control of labor quality and monitoring performance of assignments; personnel records, and others.

How does the package of applied programs in our current understanding differ from the forms used earlier to construct ASUP software?

The package of applied programs (PPP) designed for use in the ASUP is essentially a problem-oriented expansion of the computer operations

system. It provides for realizing a functionally complete data processing algorithm and includes a set of generalized program, means for generating working programs from them, and means for controlling the process of work on a job. When generating a package the user "adjusts" the programs to specific applications, giving definite values to the variable parameters of the package. In other words, the general programs included in the PPP are specialized as necessary. The PPP is a combination of program and linguistic means. The language of PPP generation and the language of queries to it insure sufficient access convenience. The packages of applied programs, which are a means to standardize ASUP's, at the same time maintain adequate flexibility to meet the specific requirements of actual enterprises.

The analysis made shows that real prerequisites have now taken shape for a firm move towards standardizing enterprise ASUP's; conditions and opportunities for formulating standard ASUP designs and aggressively introducing them at work sites now exist.

The transition to standard designing offers an opportunity to make valuable scientific-technical advances available to a large number of enterprises, insure true unity of methodology in setting up ASUP's, and considerably raise the quality of planning materials being produced.

During the Tenth Five-Year Plan a great deal of work is to be done on automation of production control. By the end of the five-year plan ASUP's should be set up at enterprises producing about 50 percent of the output of the sector. About 40 YeS computers will be delivered to enterprises and organizations of the USSR Ministry of Machine Tool and Tool Building Industry during this five-year plan.

Thus, the range of potential users of standard ASUP designs is quite broad and the challenge is to plan standard design work correctly, carry it out well, and coordinate it with the general program for setting up ASUP's in the sector.

It should be observed that during the Tenth Five-Year Plan developers are focusing their efforts on standardizing ASU designs for machine building enterprises of the sector. The reasons for this are, one, the limited number of collectives of developers and, two (and this is more important), the lack of adequate experience in development and introduction of ASUP's for the non-machine building enterprises of the sector.

Nonetheless, certain design concepts are being standardized in this five-year plan for other enterprises as well, for example tool making plants and central casting plants.

What jobs are to be done in the field of standardized ASUP design for the machine building enterprises of the sector?

As already noted above, the data base of the system is the information base of the ASUP. Standardizing the composition of indexes included in

the data base and its structure and creating sufficiently general linguistic and program means to insure control of the data base, not to mention user dialog with the data base, play an extraordinarily important part in solving the problem of standardizing ASUP's in general.

It is obvious that the composition of technical and economic indexes which must be included in the data bank as well as the composition and methodology for computing many output indexes of the ASUP depend significantly on the system of production planning adopted at the enterprise. In order to successfully resolve the problem of standardization of the ASUP, therefore, it is necessary to develop standard systems of operational planning and record-keeping for production by groups of sectors of the enterprise. Such research is already underway for the machine building enterprises of the sector.

The model structure of a data base for machine building enterprises of the sector is being worked out on this basis with due regard for the State All-Union Standards in effect for documents required in technical preparation for production and other standard documents. The appropriate design documents were issued in 1977. The package of applied programs which provides organization, servicing, and use of the data bank is planned for release in late 1978. Thus, beginning in 1978 enterprises of the sector will be able to start organizing data bases according to a standard design and beginning in 1979 they will be able to use ASUP data bank software that has been developed and tested.

The plans for standardization of ASUP's in the sector also envisions the development of standard designs for the functional subsystems, including packages of applied programs for YeS computers.

The release of packages of applied programs for the more general and easily standardized subsystems such as personnel records, monitoring performance, and quality control, is planned for an earlier time (not later than 1978). But packages for the subsystems that are more directly related to production such as technical-economic planning, control of material-technical supply, and in particular operational control of production, are to be released later, in 1979-1980. This is a result of the great complexity of constructing generalized models of production to use as the basis for putting together these packages of applied programs and the necessity of considering a large number of production factors.

The development of standard ASUP designs, in particular software for the functions being standardized, is complex and labor-intensive. Therefore, it is very important to make maximum use of the packages of applied programs already available and collected at the Tsentroprogrammsistem Science-Production Association in the city of Kalinin. Unfortunately, these packages have very limited spheres of application in the Ministry of Machine Tool and Tool Building Industry and are practically worthless for the small-series and unit production so typical of the sector. Nonetheless, wherever possible it should be planned to use these ready packages.

Thus, during the Tenth Five-Year Plan we intend to basically finish the development of sectorial packages of applied programs for the YeS computers oriented to the ASU's of machine building enterprises of the sector. It should be underlined that we are talking not only about switching to new methods of design but also about new organization for introducing ASUP designs. Proper organizational, technical, and methodological support for standardized design must be provided as well as conditions for actively introducing developed designs.

The head organization for composing standardized ASUP designs in the sector, which includes packages of applied programs, is the Khar'kov Scientific Research Institute of Automation of Control and Production (NIIAP). All the work is to be done by the ASUP development organizations of the Ministry of Machine Tool and Tool Building Industry (NIAAP, the Ryazan' branch of Orgstankinprom, the Vil'nyus territorial computing center, and the Leningrad VPTIL [expansion unknown]). This will make it possible for the process of standardizing ASUP's in the sector to be entirely controlled by the ministry, to organize precisely for development workers to accompany the packages of applied programs, and so on.

An appropriate base for standards designing is being insured by identifying three prototype enterprises with different kinds of production: the Moscow Krasnyy Proletariy Machine Tool Building Production Association (predominantly series production), the Khar'kov Machine Tool Building Production Association (predominantly small-series production), and the Leningrad Machine Tool Building Production Association imeni Sverdlov (predominantly unit production). At the base enterprises the contract designs for the ASUP's are being developed until the appropriate standard contract designs are published and detail designing and introduction are being carried on until the appropriate sectorial PPP's are released. In this way the standard designs will be based on concepts that have been tested in practice. Needless to say, in formulating the standard designs factors that are common to all enterprises of the corresponding group will be taken into account.

The development of ASUP's at base enterprises in Khar'kov and Leningrad is being done primarily by NIIAP; for the enterprises in Moscow the Ryazan' branch of Orgstankinprom is the primary developer. The Vil'nyus territorial computing center and the Leningrad VPTIL are co-performers in the development of the base ASUP's.

As already stated above, the PPP's available in Kalinin can be used to some degree for the series production enterprises. Specifically, the data bank for the system of integrated data processing and the packages of applied programs for production planning that interact with it are applicable at these enterprises. Therefore, the Ryazan' branch of Orgstankinprom is organizing its work to compose standard designs for enterprises with predominantly series production around using this specialized data bank and the corresponding PPP system.

For enterprises with predominantly small series or unit production NIIAP is developing original means to control the data bank and a system of problem-oriented packages of applied programs. The Vil'nyus territorial computing center is cooperating with NIIAP in designing the standard data base and developing sectorial PPP's for technical-economic planning while VPTIL is working with NIIAP on questions of automating control of casting production.

It has been established that the creation of a standard design for each component of the ASUP is done by stages, namely: (1) development of technical specifications; (2) development of the contract design for the base enterprise; (3) development of the corresponding standard contract design; (4) development of the detail design for the base enterprise; (5) introduction of the design at the base enterprise; (6) development and release of the sectorial PPP with appropriate operating documents; (7) transferring the PPP to the sectorial stock of algorithms and programs and organizing escort service for the PPP; (8) introduction of the PPP in industrial use at enterprises of the sector; (9) preparation of materials for publication of the appropriate sectorial standard.

The existence of a large number of multistage jobs being performed by different organizations required development of a sectorial coordinating plan for the composition and introduction of standard ASUP designs. Such a coordinating plan was drawn up and ratified by the Ministry of Machine Tool and Tool Building Industry.

Some parts of the overall job are already completed. The PPP for personnel records has been developed, turned over to the ministry commission, and successfully disseminated to enterprises; it can be used at all enterprises and organizations without exception.

Sectorial technical guidlines which regulate the composition, content, and acceptance procedure for standard ASUP designs have been worked out, approved by TsNIITU [Central Scientific Research and Production Design Institute of Control Organization and Engineering], and ratified by the Technical Administration of the Ministry of Machine Tool and Tool Building Industry. As already mentioned, work on designing a standard data base has already been completed.

Further progress of work on standard designing will depend greatly on development work at the base plant. Every effort must be made to provide the base enterprises with expanded sets of equipment, to insure model organization of jobs at these enterprises, and to place these jobs under the control of the enterprise directors. In our opinion, the Technical Administration and the appropriate All-Union production associations should take part in solving these problems.

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MULTIPROGRAM WORK IMPROVES COMPUTER EFFICIENCY

Moscow MEKHANIZATSIYA I AVTOMATIZATSIYA PROIZVODSTVA in Russian No 3, 1978, pp 36-37

[Article by engineer V. Ye. Dobrovol'skiy: "Organizing the Use of the YeS-1020 Computer in ASUP's"]

[Text] In addition to increasing the production of computer equipment 80 percent the 25th CPSU Congress pointed out the necessity of a further rise in the efficiency of automated control systems and computing centers.

An analysis of the loading of the processor and working reliability of the external units of two YeS-1020 computers was made at the group computing center of the Omsknefteorgsintez Production Association in order to study the possibilities of improving computer use. Of course, with the YeS-1020 the operations of the primary program and input-output can be done in parallel. But because the external units work much more slowly than the processor, the control program often switches the processor to a condition of "waiting" for input-output operations to be completed.

A machine timer which recorded the processor's "waiting" time after performance of the program was used to analyze the loading of the YeS-1020 processor. The total working time was recorded with a stop watch. The analysis was performed for nine economic problems that had already been introduced. The figures obtained in this way are shown in Table 1, from which it follows that the workload of the processor ranges from 15 to 43 percent of machine time. The reason for this is the fact that solving economic problems requires a large volume of data stored in external memory and thus required a large number of input-output operations. The retrieval and forwarding of the necessary data to the processor takes a great deal of time.

The time spent performing programs is reduced by organizing multiprogram computer work. This improves the use efficiency of the processor by combining the input-output operations of one problem with the processor operations of another. The DOS-YeS supervisor, which controls the

Problem Title	Program Worktime, min.	Processor "Waiting" Time, min.	Processor Workload, %
Summary of Shipments by Tank Cars	10.33	6.56	36.5
Summary of Production	30.25	25.71	15
Summary of Shipments by Tonnage	25.00	20.86	19
Summary of Air Pollution	13.50	9.33	31
Mixing of Oils	28.00	22.02	21
Urgent Diagrammatic Charts	21.83	13.16	40
General Diagrammatic Charts	50.41	28.95	43
Analysis of Fuel Expenditure	18.33	13.03	29
Planned Need and Cost of Reagents	124.45	79.83	36

YeS-1020, is capable of handling multiprogram work. It can perform up to three independent programs simultaneously. Each problem program is performed in one of the three sections of the main internal memory. Experience with operating two machines shows that organizing multiprogram computer work faces the following complicating factors:

1. All external units of the machine are distributed among sections of main internal memory. One external unit cannot be assigned simultaneously to several divisions, except for typewriters and magnetic disc storage;

2. The existence of large volumes of information makes it impossible to use the same package of discs to solve several economic problems;

3. Convenience of preparation and the possibility of repeating part of the program when a malfunction occurs in a particular assignment make the punched card reader the primary unit for feeding control statements;

4. The use of magnetic tape storage for intermediate storage of output data which is then printed out on an alphanumeric printer when the output tabulator messages contain more than 120 line symbols makes it more difficult to program input-output. It is usually necessary to analyze some intermediate results in the course of problem solving, especially during debugging; therefore, it is not always expedient to use magnetic disc and magnetic tape storage for intermediate results.

To achieve more flexible multiprogram work it is necessary to expand the existing minimum set of external units by acquiring magnetic disc storage, alphanumeric printers, and punched card readers.

One characteristic of the operation of these two machines is that one of the YeS-1020 computers has just one magnetic block of main internal memory. All the problems solved at the group computing center were worked out figuring on a main internal memory volume of 64 kilobytes. Today, with the increase of main internal memory volume in this machine to 128 kilobytes, reprogramming problems for multiprogram operations is much simpler. Switching all problems to computers working in the multiprogram mode with an expanded minimum set of external units does not take much time. The introduction of multiprogram computer work raises the efficiency of the association automated control system.

One of the primary requirements made of the ASUP [enterprise automated control system] is reliable, timely representation of information. As the association ASU [automated control system] has developed through the introduction of new problems conditions for information output by a definite time have become more rigid. The time reserve for recalculation of an incorrectly solved problem and even for correcting it is steadily diminishing. Other, equally important problems appear in the queue and solutions to them cannot be put aside for a few hours because information produced 2-3 hours late loses its value. The ASUP must have a time reserve when solving operational problems by computer in order to provide reliable, good quality work; if it does not there may be violations of the schedule for supplying information to the production services.

One of the problems of the reliability of the automated control system as a whole is the reliability of work of the ASUP hardware. If a computer goes down it often leads to a breakdown of the schedule of computing work and failure to deliver operational information on time. The average time required to eliminate malfunctions ranges from 20 minutes to 2-3 hours and can increase sharply where necessary spare parts are not available. A study made of time spent on repairs for two YeS-1020 computers over a period of 12 months produced the following figures. The first machine had an effective period of working time of 2,983 hours and 410 hours were spent for repair: 28 hours on the processor, 230 hours on external units of the multiplex channel, and 152 hours on external units of the selector channels. The second machine had an effective period of working time of 3,122 hours and 449 hours were spent on repair: 46 for the processor, 210 for external units of the multiplex channel, and 196 to repair external units of the selector channels. From this it can be seen that the average reliability of the processor is an order greater than the reliability of the external units. Introducing multiprogram work and, in connection with this, increasing the number of external units makes it possible to use all the resources of the computer more fully, increases the reliability of the computing complex, and promotes more rhythmic work by the entire production automated control system.

The malfunctioning of one external unit does not by itself mean that the operational accounting schedule will be violated. In such extreme cases the availability of other identical external units makes it possible to organize single-program work on the computer.

The expected annual economic effect from introducing two-program work for the YeS-1020 computer was calculated on the basis of the following raw data: 70 percent rise in computer productivity; cost of one machine hour 80 rubles; effective period of computer work 3,000 hours; machine downtime for repair of external units 400 hours.

The following formula was used:

$$E = \Delta S - K_n C$$

where E = 186.26 rubles, the annual economic effect; ΔS is 200,000 rubles, the total savings received as a result of reducing machine downtime by repairing external units (32,000 rubles) and raising computer productivity (168,000 rubles); K_n = 0.15, the normative coefficient of capital investment; C = 91,6000 rubles, the additional capital investment to purchase and debug one NMD YeS-5052 (25,400 rubles), a YeS-6012 punched card reader (25,800 rubles), and a YeS-7032 alphanumeric printer (40,500 rubles).

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SOKOL'NIKI EXHIBIT FEATURES FOREIGN OFFICE, PLANT EQUIPMENT

Moscow MEKHANIZATSIYA I AVTOMATIZATSIYA PROIZVODSTVA in Russian No 3, 1978 pp 47-48

[Article by Ye. T. Larina: "Systems Engineering-77"]

In December 1977 the specialized exhibit Systems Engineering-77 was held in Sokol'niki to familiarize specialists with various products of foreign firms: electronic monitoring and measuring instruments and systems, data processing and transmission equipment, dictaphones, office furniture, and the like.

The Aristo Company of West Germany showed equipment for processing data on two-dimensional and three-dimensional geometric figures, processing and storing these data in an archive, or reproducing them in the form of a flat or three-dimensional image.

The Aristo Company is developing systems of geometric data processing oriented to various fields of application; at the present time the systems are used in cartography, geodesy, and at municipal and domestic service enterprises.

The modular system Aristogrid ZD, which was displayed at the exhibit, consists of a device which converts graphic originals into digital information and computers with dialog displays for data processing; the data is reproduced by a drawing unit or microfilm plotter for flat images. With due regard for technological requirements machine tools with digital control can in many cases work with one-time data.

With the basic unit, the Aristogrid series 100, and a sensitive element or pin, it is possible to convert originals of any dimensions up to 1,000 x 1,500 millimeters into digital information.

A modification of the system of displays of the Aristogrid ZD400 has a powerful computer to which four units with displays may be connected. The multiunit Aristogrid ZD500 system is designed to control data arising and being processed at work points with Aristogrid ZD300 displays (between one and 20 of them); control is exercised by a central processor.

The operator of the Aristogrid ZD300 display at each work point has a computer with disc memory that insures completely independent functioning.

The Rena Company of West Germany displayed a number of addressing machines for various purposes, from the model 201 Rena manual addressing machine to the electrical model 1,200. The electrical Rena model 1,200 addressing machine produces 3,000 address labels an hour. The address is carried by a master form typed on a Rena typewriter and held in a plastic frame. This is a compact machine that goes in a case. The standard model allows individual impressions to be made by pressing a foot pedal. A packet with the ready impression is automatically ejected. The machine can also be equipped with automatic electric eye control; when a package stacker is installed the machine becomes automatic.

The West German company Stenokord Elektronik had an extensive display of dictaphones at the exhibit. The Tel-Ediset is a remote dictating unit in which cassettes are replaced automatically. After the dictation is completed an automatic rewind block is triggered and in this way someone coming later can neither listen to nor erase the text of the earlier dictator.

The Stenokord 653 remote dictating unit is used in industry, trade, institutions, schools, and hospitals. The unit provides telephone communication between any dictation point and a central typing bureau. Travel between the dictator and the typist, which usually takes a great deal of time, becomes completely unnecessary.

The Stenokord Company exhibited an original device for recording and reproducing sound on dictocuffs and minicassettes in the same device. This is a pocket dictaphone, a "talking notebook."

The West German firm Triumph-Adler exhibited a telecoder for streamlining teletype communications. All messages can be transmitted immediately after printing. This eliminates the necessity of the usual double printing of the text and saves time and money as well as reducing the number of mistakes.

The French firm Cisie Ingenierie displayed a dialog minicomputer for the APL language. The machine is figured for several users and performs scientific and technical computations. It consists of a high-speed central unit, a ferrite memory with a capacity of 32,000 words (16 bytes/ 64 kilobytes), and a microprogram with a capacity of 5,000 words/36 bytes; an asynchronous connecting plate (1-6 terminals), a clock, a disc controller, a disc with a capacity of 10 (2 x 5) Mbytes, a printer that writes 45 characters a second, a mixed keyboard, and a desk.

The Cisie Association is developing programming means used in various fields. For example, there is the Realite-20, a control system for primary data arrays that serves different customers and uses numerous

programs. The system has a microprogrammable computer that uses magnetic discs. The Cisie Association has developed a control language for fulfilling possible contracts with the Soviet Union. A Realite-20 system has been supplied to the USSR Central Statistical Administration. Control systems based on small and medium-sized computers of the Realite-20 type have some advantages over traditional systems: data redundancy is eliminated, ordering procedures are simpler, and independence from other arrays and programs is preserved.

The French Cercie Society displayed automated production process and enterprise control systems for metallurgy, the petroleum industry, automotive plants, warehouses, and the like.

Hewlett-Packard of the United States displayed monitoring and measuring instruments and systems controlled by microprocessors. The instruments are used in science, industry, health, and other fields. The model 3052A automated data collection system checks parameters and reaction to external influences, analyzes signals during industrial testing and laboratory investigations, and monitors industrial processes. The system includes a digital voltmeter, input multiplexor, high-productivity calculator, and plotter-printer. The fact that the system has two digital volt meters gives it high speed and precision of measurement.

A number of recording devices used in industry, scientific research, and medical institutions were also exhibited. Among them were coordinating automatic tape recorders, oscillograph registers, magnetic recording units and others.

The Dutch firm GAF exhibited the GAF-1200 DA light copying unit intended for the design bureaus of industrial enterprises. The device produces a large number of light copies in a short time. Paper for copying is fed automatically and sheets of identical length to the original are cut off automatically. A roll of light copying paper 300 meters long is put on the feed rollers; an additional roll 100 meters long for manual feeding is specially intended for special types of work, for example light copying of the primary tracing design and so on. The machine has an attachment that makes it possible to select the appropriate roll automatically when feeding the original. The GAF-1200 DA works by a dry process.

The GAF-480 DA is figured for program control; the machine can work simultaneously with one, two, or three originals of the same or different dimensions. When the original is fed the GAF-480 DA device "chooses" the necessary roll width. The unit is now being used in the aviation, automotive, and power industries.

The Finnish company A/O Televa displayed the Timekon-200 system for monitoring staggered working time. The system counts and displays deviations from the normal working time in order to mark arrival at the institution and departure from it at the end of the working day. The system consists of a central unit and 1-8 terminals.

A digital panel ordinarily shows the time; when the card is put into the printer the digital panel shows the former total. When any button is pressed it shows the new total of work time with a plus or minus sign.

The terminal device is installed on a stairwell (or story). The number of such devices depends on the number of personnel, generally one unit for 200 people.

Whenever requested the central unit prints a list of the current workday's postings and the total for any workday. The effect of an erroneous or short posting may be corrected in the total.

Advances by foreign ergonomics were displayed at the exhibit: furniture, furnishings for the work place, and the like. The office and file furnishings from the Electrolux-Kachete deserve attention. A sliding rack is the most economical for archives and warehouses from the point of view of using space and makes access to material being stored easier.

The firm also offered the Elux wall for planning industrial environments. For example, they had a work break room which was a soundproofed room used at industrial enterprises and requiring only limited space.

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INVESTIGATING THE EXCITATION OF ACOUSTIC WAVES IN PLATES

Kiev IZVESTIYA VUZ -- RADIOELEKTRONIKA in Russian Vol 21 No 3, 1978 signed to press 21 Mar 77 pp 25-28

[Article by V. V. Burliy, I. Ya. Kucherov, I. V. Ostrovskiy and V. M. Perga]

[Text] The excitation of zero modes of acoustic waves in plates yz - $LiNbO_3$ is considered. It is shown that single-phase arrays and interdigital transducers (VShP) for waves in plates are described by formulas for VShP of surface waves. The experiments were carried out on plates 80 microns thick where the symmetrical S_0 and antisymmetrical a_0 modes were excited in the range of 4.5-17 MHz. Measurement of the dependence of the conductivity of transducer emission on frequency and the number of periods agree with those calculated theoretically. The introduced losses in the matched mode were 9-10 dB at a band of 13 percent.

The properties of acoustic waves of different types in crystalline solids (volume waves, surface waves, Gulyayev-Blushtein waves, waves in plates and so on) are now being investigated extensively for use in electroacoustic devices. Excitation and detection of acoustic waves occupies an especially important position both to investigate their properties and for their practical use. This problem may be regarded as rather completely solved for volume and surface waves [1, 2]. With regard to acoustic waves of other types, their excitation and detection have essentially not been investigated and there are only a few investigations [3]. This communication is devoted to investigation of the excitation of acoustic waves in piezoelectric plates.

The object of the investigation was $LiNbO_3$ crystals. It is known [4] that acoustic waves generally do not decompose into Lamb waves and transverse waves in plates of class C_{3v}, to which lithium niobate is related in the general case and sometimes even during propagation along crystallographic axes. This occurs only in plates of yz- and zy-sections. Lamb waves are piezoactive in both these cases. The excitation of zero modes of Lamb waves in plates of yz-section is investigated in this paper by means of interdigital transducers (VShP) and single-phase arrays (OR) -- Figure 1. The operation of transducers is analyzed by means of equivalent circuits [5].

Let us consider a plate on whose surface electrodes are placed which form a single-phase array (Figure 1). Mechanical forces F occur upon application of voltage which excites ultrasound (Figure 1, a). Since the two adjacent sections of the plate with length 1/2 (under the metal electrode and in the gap) are subjected to tensile and compressive stress in the counterphase, they may be represented as two rods connected acoustically in series and electrically -- antiparallel (Figure 1, b). Each rod, vibrating along the length in an electric field perpendicular to the propagation of the acoustic wave, is described by a known equivalent Mason circuit [6]. VShP, as is done in [5], may also be represented in a similar manner. The fact that the real electric field distribution pattern between the VShP electrodes (Figure 1, c) is replaced by an approximate pattern (Figure 1, b) with a single transverse field component is justified by the similarity of the zero modes of waves in plates to a surface wave. And the mutual energy related to the transverse electric field component for a surface wave in yz -- $LiNbO_3$ is 10 times greater than that related to the longitudinal component [5]. Thus, one periodic section with length 1 may be represented in a single-phase array and in VShP by two equivalent Mason circuits connected acoustically in series and electrically -- antiparallel. The entire transducer containing N periodic sections may be represented as the combination of N equivalent circuits of one section connected acoustically in series and electrically in parallel. Consequently, the total equivalent circuit in this transducer will be exactly like that for VShP of surface waves in approximation of the transverse exciting field [2, 5]. The electric input (output) of the transducer may then be represented near the resonance frequency f_0 ($f = f_0 \pm 20$ percent) by a circuit (Figure 1, d) found in [5] for surface waves. Moreover, the active conductance G(f) and the reactance G(f) of the transducer are equal [5]:

$$G(f) = G_0(f_0)\left[\frac{\sin x}{x}\right]^2 = 8K^2_{\text{эф}} f_0 C_n N \times \times \left[\frac{\sin \dfrac{N\pi(f-f_0)}{f_0}}{\dfrac{N\pi(f-f_0)}{f_0}}\right]^2, \tag{1}$$

$$B(f) = G_0\left[\frac{\sin 2x - 2x}{2x^2}\right]; \qquad B(f_0) = 0. \tag{2}$$

The value of C_p is the total static capacitance of the entire transducer; K^2_{ef} is the square of the effective coupling constant which characterizes the effectiveness of ultrasound excitation (it is different for different modes).

The energy losses to electroacoustic transformation in the matched mode are equal to [2, 5]

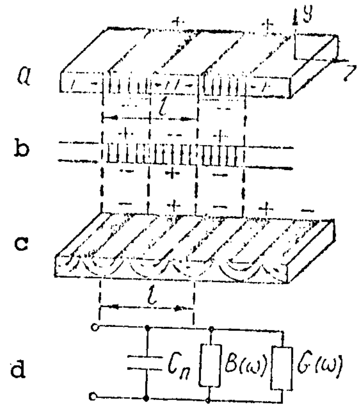

Figure 1. Single-Phase Arrays of Period l (a); Periodic Section of Transducers With Length l Represented as Two Half-Wave Rods (b); VShP of Period l (c); Equivalent Circuit of Latticed Transducers of Lamb Waves Near Resonance Frequency (d)

$$P\,[dB] = -10\lg\frac{2b}{(1+b)^2}, \tag{3}$$

where $b = G_n/G_0$; G_n is the active conductance of the transducer load. The conversion frequency band is determined by the frequency functions G(f) and B(f) and by the electric bandpass of the tuned circuits ($G_0/2\pi f_0 C_p$) [7-9]. And one can calculate P(f) by formulas (3) and (1) only in the case of equality of the electric and acoustic band, which is determined by G(f). It is assumed in this case that the imaginary component of transducer impedance is compensated for by the tuned elements over the entire band.

Experiments were carried out with two yz -- $LiNbO_3$ plates 80 microns thick, 9 mm wide and 31 mm long. The specimens were cut from the same monocrystal and were then polished. The accuracy of orientation by the z and y axes was 1 and 2°, respectively, and the basic surfaces of the plate were optically polished.

The investigations were carried out in the frequency range of 4.5-17 MHz, where two zero modes, similar to zero antisymmetrical (a_0) and zero symmetrical (S_0) modes in plates of hexagonal crystals, were excited. One of them (S_0) was dependably excited over the entire investigated frequency range, while the second (a_0) was excited only in the region of 5 MHz. The S_0 mode in this frequency range undergoes slight dispersion: its phase velocity varied from $7\cdot10^5$ cm/s at f = 6 MHz to $6.7\cdot10^5$ cm/s at f = 17 MHz. The phase velocity of mode a_0 at frequency of f = 5 MHZ was equal to $2\cdot10^5$ cm/s. VShP (l = 0.9 mm) were applied to specimen No. 1 for excitation of mode S_0 at frequency of 7.9 MHz. Single-phase arrays were applied to specimen No. 2 (l = 0.4 mm), which permit excitation of mode S_0 at frequency of 16.6 MHz, and also of mode a_0 at frequency of 5 MHz. The transducers

were 8 mm wide. The lower surface under the single-phase transducers was coated with metal. All the transducers were tuned by parallel-connected inductances during measurements of G and also during measurements of the introduced losses.

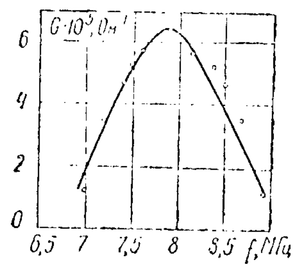

Figure 2. Dependence of Conductance of VShP Emission on Frequency for Mode S_0. Line -- theory; points -- experiment

The results of measuring VShP conductivity with different number of periods N on specimen No. 1 at resonance frequency f_0 = 7.9 MHz are presented in Table 1. The theoretical value of conductance G_{0t} was calculated by formula (1) at values of K^2_{ef} = 0.041, which is in good agreement with data from the literature for surface waves [1, 2, 5]. This value of K^2_{ef} was selected to tie in experimental and calculated data at N = 5. The results for measurements G(f) of this same VShP at N = 20 are presented in Figure 2. The theoretical curve was calculated by (1). The emissive conductance of a single-phase array (OR) was measured in specimen No. 2 as a function of the number of its hatchures (N) at resonance frequency of f_0 = 16.6 MHz. The results of these measurements are presented in Figure 3. Tying by K^2_{ef} was carried out at N = 20. It turned out that for this case K^2_{ef} = 0.014. As a result, instead of VShP, single-phase arrays of period 1 = 0.6 mm were applied to specimen No. 1. A value of K^2_{ef} = 0.018 was found from measurements of G_0 of this transducer which excites mode S_0 at f_0 = 11 MHz. Measurements of G_0 yielded K^2_{ef} = 0.004 for mode a_0 excited by an OR in specimen No. 2.

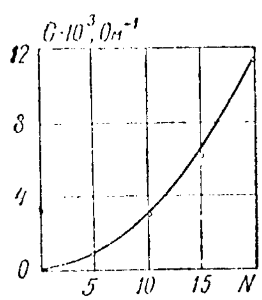

Figure 3. Dependence of Emissive Conductivity of Single-Phase Array on Number of Electrodes for Mode S_0: line -- theory, points -- experiment

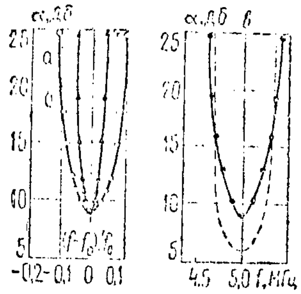

Figure 4. Losses to Double Electroacoustic Transformation (α): a -- mode S_0; VShP ($N = 5$, $l = 0.9$ mm, $G_0 = G_n = 6.5 \cdot 10^{-5}$ ohms^{-1}); $f_0 = 7.8$ MHz; b -- mode S_0, OR ($N = 20$, $l = 0.4$ mm, $G_0^{-1} = 87$ ohms and $G_n^{-1} = 75$ ohms), $f_0 = 16.6$ MHz; c -- mode a_0, OR ($N = 20$, $l = 0.4$ mm and $G_0 = G_n = 10^{-3}$ ohms^{-1}); dashed line -- theory

Table 1

N	5	4	3	2
$G_0 \cdot 10^3$, Ом$^{-1}$	6,5	4,4	2,7	1,2
$G_{0T} \cdot 10^3$, Ом$^{-1}$	6,5	4,2	3	1,2

The losses of electroacoustic transformation upon excitation of S_0 and a_0 were also measured. Experiments with mode S_0, excited by a single-phase array, were carried out in a standard 75-ohm channel, and when operating at a_0 and S_0 with VShP, additional matching was carried out in order that G_0 was equal to G_n at frequency f_0. The results of these investigations are presented in Figure 4. The data of theoretical calculations (dashed line) are presented here for case (c). The number of periods N for cases (a) and (b) differed significantly from the optimum $N_0 = \sqrt{\pi / 4K_{ef}^2}$ [1, 2, 5]; therefore, no theoretical calculations were made. It is obvious that the experimentally derived minimum losses are 3 dB higher than theoretical. This may be explained by the diffraction losses during propagation of a wave in a plate and by losses in the matching circuits jointly with the transducer electrodes, which have finite conductance. Additional losses were also caused by the possible disorientation of axes in the specimens. We note that additional losses of 3-6 dB are usually observed upon excitation of surface waves [2, 10].

The investigations showed that acoustic waves in piezoelectric plates may also be effectively excited, the same as surface waves (total losses at frequency of f_0 were 9-10 dB for zero modes of Lamb waves).

BIBLIOGRAPHY

1. Morozov, A. I., V. V. Proklov, V. A. Stankovskiy and A. D. Gingis, "P'yezopoluprovodnikovyye preobrazovateli ikh primeneniye" [Piezosemiconductor Transducers and Their Application], Moscow, Energiya, 1973.

2. Karinskiy, S. S., "Ustroystva obrabotki signalov na ul'trazvukovykh poverkhnostnykh volnakh" [Signal Processing Devices Based on Ultrasonic Surface Waves], Moscow, Sovetskoye radio, 1975.

3. Toda, K., "Lamb Wave Delay Lines With Interdigital Electrodes," J. APPL. PHYS., Vol. 44, No. 1, 1973.

4. Borovkov, O. V. and I. Ya. Kucherov, "Normal Elastic Waves in Crystal Plates of Class C_{3v}," UFZH, Vol. 17, No. 12, 1972.

5. Smith, W. R., H. M. Gerard, J. H. Collins, T. M. Reeder and H. J. Shaw, "Analysis of Interdigital Surface Wave Transducers by Use of an Equivalent Circuit Model," IEEE TRANS., MTT-17, No. 11, 1969.

6. "Fizicheskaya akustika" [Physical Acoustics], edited by W. Mason, Vol. 1, Part A, Moscow, Mir, 1966.

7. Hartman, C. S., D. T. Bell and R. S. Rosenfeld, "Impulse Model Design of Acoustic Surface Wave Filters," IEEE TRANS., MTT-21, No. 4, 1973.

8. Gerard, H. M., W. R. Smith, W. R. Jones and J. B. Harrington, "The Design and Applications of Highly Dispersive Acoustic Surface Wave Filters," IEEE TRANS., MTT-21, No. 4, 1973.

9. Reeder, T. M. and D. K. Winslow, "Characteristics of Microwave Acoustic Transducers for Volume Wave Excitation," IEEE TRANS., MTT-17, No. 11, 1969.

10. Smith, W. R., H. M. Gerard, J. H. Collins, T. M. Reeder and H. J. Shaw, "Design of Surface Wave Delay Lines With Interdigital Transducer," IEEE TRANS., MTT-17, No. 11, 1969.

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ENGINEERING AND EQUIPMENT

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MEASURING SELSYN ROTOR ANGLE OF ROTATION CONVERTER

Leningrad IZVESTIYA VUZ - PRIBOROSTROYENIYE in Russian Vol 21 No 2, 1978 signed to press 12 Mar 78 pp 5-8

[Article by T. M. Aliyev, R. M. Mirsalimov and V. B. Ibragimov, Azerbaydzhan Institute of Petroleum and Chemistry imeni M. Azizbekov]

[Text] The diagram of a device for linear conversion of a selsyn rotor angle of rotation to an electric signal phase and further to digital code is considered.

Electromechanical displacement converters, among which selsyns have achieved wide distribution, are now used to monitor various parameters in many fields of industry. These micromachines are specifically contained in devices for remote monitoring and analog recording of the main indicators which characterize the drilling process [1].

As is known, a selsyn has nonlinear conversion characteristics. This determines the series connection of a linearizing device with it, as which may be used analog [2] and digital [3] correcting circuits, nonlinear voltage dividers [4] and varieties of them, which usually realize the piecewise approximation method. The enumerated hardware makes it possible to solve the postulated problem but the circuit is complicated in this case and the measurement accuracy is reduced due to the presence of a significant methodical error and error due to the instability of the power supply system parameters.

The indicated deficiencies are reduced by construction of a converter by the diagram with intermediate conversion to phase shift [5]. Let us consider a device which is related to this class. It contains (Figure 1) a selsyn, a matching transformer T, a linearization block (BL) which compensates for nonlinearity of the selsyn conversion characteristic and a phase measurement block (BIF).

The matching transformer T is constructed by the "triangle-star" circuit with grounded mid-point; it provides galvanic decoupling in the selsyn-linearization block circuit and also scaling of the selsyn output voltages. The BL is made on the basis of an integrated operational amplifier (OU) and has a transfer characteristic determined by the expression [6]:

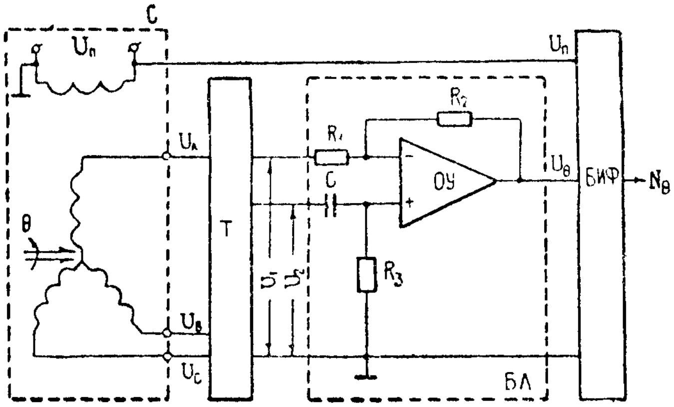

Figure 1

$$U_\theta = -\frac{R_2}{R_1} U_1 + \left[\left(\frac{R_2}{R_1} + 1\right)\left(\frac{1}{1 - j\frac{1}{\omega C R_3}}\right)\right] U_2. \quad (1)$$

The effect of linearization of the selsyn conversion characteristic is achieved by selecting the ratio between elements contained in the BL and connected to the input circuits and the feedback circuit of the OU (R_1, R_2, R_3 and C) which provides a directly proportional function between one of the voltage parameters (phase in the given case) U_p and the angle of rotation θ. Actually, if the following conditions are fulfilled

$$R_1 = R_2; \quad \omega C R_3 = \frac{1}{\sqrt{3}}, \quad (2)$$

expression (1), after substitutions and intermediate calculations, is reduced to the form

$$U_\theta = -kU_m \sin(\omega t - \theta + \alpha), \quad (3)$$

where k = const; α = const.

Thus, a voltage U_θ with constant amplifute and variable phase which varies linearly as a function of the angle of rotation θ of the selsyn rotor, is formed at the BL output. If the constant phase shift α is compensated for by one of the known methods, for example, by phase bias of the power supply voltage U_p, which is selected as a reference signal, the voltage phase U_θ can be measured comparatively simply. The flip-flop phasemeter circuit usually employed for this purpose contains two comparators whose error of nonidentity is directly contained in the total error of digital measurement of the angle of rotation θ. In the considered converter the phase measuring block BIF (block diagram -- Figure 2, a; force-displacement time

diagrams -- Figure 2, b) contains only one comparator K to whose output voltages U_p and U_θ, shifted in phase by angle θ, are connected alternately as a function of the position of switch P.

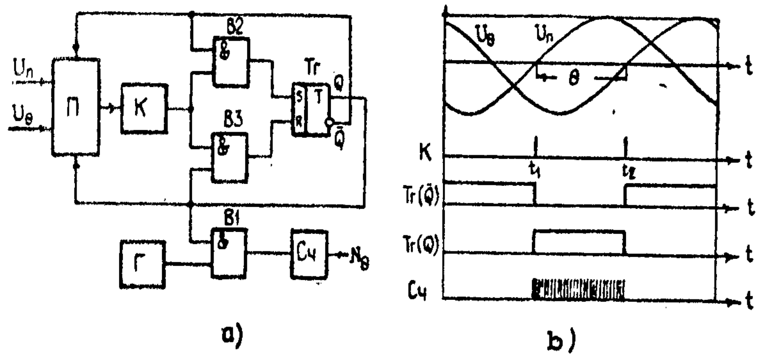

Figure 2

At the initial moment of time the flip-flop Tg of the BIF block is in the "zero" position: a low potential close to zero is located at its output Q (therefore, gate B1 is closed), while a high potential is at output $\bar{Q}$ which sets the switch P to the position at which voltage U_p is fed to the comparator input K. At moment of time t_1 corresponding to transition of this voltage through zero, comparator K emits a short pulse which passes through open gate B2 to input S of flip-flop Tg and transfers it to the "1" position. Gate B1 is opened and pulses from the generator G begin to fill the counter Sch. At the same time voltage U_p is cut off and voltage U_θ is fed to the input of comparator K through switch P, set to the corresponding position by the resolving potential from output Q of flip-flop Tg.

At moment of time t_2, corresponding to transition of voltage U_θ through zero, comparator K emits a second pulse which passes through the open gate B3 to the input R of the flip-flop Tg and again transfers it, returning it to the initial "0" position. Gate B1 is closed in this case and the arrival of pulses to the counter Sch stops. The content of the counter, proportional to the angle of rotation θ, are counted. The high potential at the output $\bar{Q}$ of flip-flop Tg prepares the gate B2 for passage ofthe next pulse of the comparator K, to whose input voltage U_p is connected through switch P set to the corresponding position and the phase measuring block BIF is ready for the next measuring cycle.

Experimental investigations of the measuring converter were carried out at $R_1 = R_2 = 3.9$ kOhms, $R_3 = 1.85$ kOhms and C = 1 microfarad. The values of the angle of rotation θ of the selsyn rotor were established by the scale of the dividing head with accuracy of 3.6', while the voltage phase U_θ was measured by the described method with an accuracy of 0.05 percent. The nonlinearity of the conversion characteristics over the entire range of variation of angle of rotation θ did not exceed 0.2 percent.

A device of this type may find application in information-measuring systems in which selsyns are used as angular position sensors.

BIBLIOGRAPHY

1. Porter, L. G. and V. S. Basovich, "Pribory nazemnogo kontrolya protsessa bureniya -- Obzor" [Devices for Ground Monitoring of the Drilling Process -- A Survey], Moscow, VIEMS, 1971.

2. Vasil'yev, V. K. and B. K. Kurilenko, "Contactless Angle of Rotation Sensor," Author's Certificate of the USSR No. 377856, BYULLETEN' IZOBRETENIY, No. 18, 1973.

3. Kollataj, J. H. and T. Harkonen, "Integrated Circuits in Action, Part 10, Linearizing Sensor Signals Digitally," ELECTRONICS, Vol. 41, No. 5, 1968.

4. Schmid, H., "An Electronic Design Pracital Guide for Synchro-to-Digital Converters," Part 2, ELECTRONIC DESIGN, No. 7, 1970.

5. Anisimov, V. A. and A. A. Plaks, "A Device for Measuring the Angle of Rotation of an Asymmetrical Selsyn Pair," Author's Certificate No. 310281, BYULLETEN' IZOBRETENIY, No. 23, 1971.

6. Espen, D. A., Constant Amplitude-Variable Phase Circuit, USA Patent, cl. 323-109, No. 3617863, patented, 1971.

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ENGINEERING AND EQUIPMENT

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THE EFFECT OF LINEAR ACCELERATION ON THE STABILITY OF A DYNAMICALLY TUNED PRECESSION GYROSCOPE

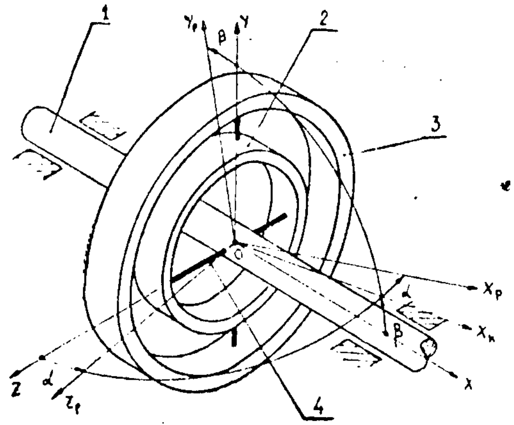
Leningrad IZVESTIYA VUZ - PRIBOROSTROYENIYE in Russian Vol 21, No 2, 1978 signed to press 12 Mar 78 pp 72-76

[Article by V. A. Kuzinov, Leningrad Institute of Precision Mechanics and Optics]

[Text] The stability of a Howe gyroscope is investigated in the presence of radial unbalancing of the rotor and the middle band ring in the field of one-component radially aligned linear acceleration of the base is investigated. The gyroscope equations, after a number of transformations, are represented in the form of a matrix power series by powers of small parameter. The representative matrices of the first and second approximations by which the stability of the gyroscope is analyzed are determined on the basis of methods used to investigate matrix equations with small parameter.

A number of papers has been devoted to investigation of the motion stability of gyroscopic devices [1-3]. The effect of one-component radially aligned linear acceleration of the base on the stability of a dynamically tuned precession gyroscope, made by the Howe scheme (figure), is analyzed in this article on the basis of vector-matric representations of the differential equations of a gyroscope and use of methods of investigating these types of equations. An intermediate band ring 2 is attached by means of torsion bars 4 to a shaft 1 rotated at angular velocity. The rotor 3 is connected to the intermediate band ring by a pair of similar torsion bars located in the plane of the ring and rotor perpendicular to the first pair of torsion bars.

The case when the centers of mass of the rotor and of the intermediate band ring are shifted in positive directions of the bound axes O, x_r, y_r, z_r and O, x_k, y_k, z_k by values of u_r and z_r for the rotor and u_k for the ring is considered.



The differential equations of undisturbed motion with respect to the coordinate system O, x, y, z, which does not participate in natural rotation of the rotor and ring, may be represented in dimensionless form in the following manner [1]:

$$\begin{gathered}\frac{1}{2}(2e-c)\alpha'' - \frac{1}{2}c(\alpha''\cos 2\tau + \beta''\sin 2\tau) + h\beta' + c(\alpha'\sin 2\tau - \beta'\cos 2\tau) + \\ + \varepsilon^2\sigma\alpha + \varepsilon b_0(\alpha\cos 2\tau + \beta\sin 2\tau) + \varepsilon\varkappa\alpha' + \varepsilon\varkappa_2\beta = 0, \\ \frac{1}{2}(2e-c)\beta'' - \frac{1}{2}c(\alpha''\sin 2\tau - \beta''\cos 2\tau) - h\alpha' - c(\alpha'\cos 2\tau + \beta'\sin 2\tau) + \\ + \varepsilon^2\sigma\beta + \varepsilon b_0(\alpha\sin 2\tau - \beta\cos 2\tau) + \varepsilon\varkappa\beta' - \varepsilon\varkappa_2\alpha = 0,\end{gathered} \tag{1}$$

where $b_0 = \frac{1}{2}[\varepsilon^2(c_\alpha - c_\beta) + b]$, $\varepsilon = \frac{1}{\Omega}$; $\sigma = \frac{1}{2}[\varepsilon^2(c_\alpha + c_\beta) - b]$ is the dynamic detuning of the gyroscope; $J_{z_p} + J_{z_к} - J_{y_p} = c$; $J_{z_p} + J_{z_к} = e$; $J_{x_p} + J_{z_к} = h$; $\varkappa_1 + \varkappa_2 = \varkappa$; J_{x_p}; J_{y_p}; J_{z_p}; $J_{x_к}$; $J_{y_к}$; $J_{z_к}$ are the moments of inertia of the rotor and ring; Ω is the rotational speed of the rotor and ring; c_α and c_β are the angular stiffness of the rotor and ring suspension; and x_1 and x_2 are the coefficients of the moments of internal and external frictional forces.

The following moments occur with respect to the axes of gyroscope sensitivity in the presence of displacements of the centers of mass of the rotor and ring and with the effect of radially aligned acceleration $\bar{j}$, expressed in projections onto the Rezal' axes j_x and j_y:

$$\begin{aligned} M_y &= \varepsilon^2(r_1\cos\tau + q_1\sin\tau)\beta - \varepsilon^2(r_2\cos\tau + q_2\sin\tau)\alpha - \varepsilon^2 S_{к_1}\sin 2\tau - \varepsilon^2 S_1 \\ M_z &= \varepsilon^2(r_1\sin\tau - q_1\cos\tau)\beta - \varepsilon^2(r_2\sin\tau - q_2\cos\tau)\alpha + \varepsilon^2 S_{к_2}\cos 2\tau + \varepsilon^2 S_2, \end{aligned} \tag{2}$$

$$\begin{gathered}\text{где } r_1 = j_y m_p z_p;\ q_1 = j_y(m_p y_p + m_к y_к);\ r_2 = j_z m_p z_p;\ q_2 = j_z(m_p y_p + m_к y_к); \\ S_{к_1} = \frac{1}{2} j_y m_к x_к;\ S_{к_2} = \frac{1}{2} j_z m_к x_к;\ S_1 = j_y\left(m_p x_p + \frac{1}{2} m_к x_к\right);\ S_2 = \\ = j_z\left(m_p x_p + \frac{1}{2} m_к x_к\right);\end{gathered} \tag{2}$$

and m_k and m_r are the masses of the ring and rotor; x_r, y_r, z_r, x_k and y_k are the displacements of the centers of mass of the rotor and ring in positive directions of the bound axes.

The nature of gyroscope motion in the presence of components S_{k_1}, S_{k_2}, S_1 and S_2 is rather well known; therefore, the effect of parameters r_1, r_2, q_1 and q_2 is subsequently analyzed.

By using vector X with components $x_1 = \alpha'$, $x_2 = \beta'$, $x_3 = \alpha$ and $x_4 = \beta$, system (1) is reduced to a single vector equation with regard to moments (2) in which for simplicity the gyroscope is assumed to be completely symmetrical (C = 0):

$$\frac{d\bar{x}}{d\tau} = [A + \varepsilon B_1 + \varepsilon^2 B_2]\,\bar{X}, \tag{3}$$

where

$$A = \begin{Vmatrix} 0 & -\omega & & \\ \omega & 0 & & 0 \\ & 1 & & 0 \end{Vmatrix}; \quad B_1 - \frac{1}{\omega e}\begin{Vmatrix} -\varkappa & 0 & 0 & -\varkappa_2 \\ 0 & -\varkappa & \varkappa_2 & 0 \\ & 0 & & 0 \end{Vmatrix};$$

$$B_2 = \frac{1}{\omega e}\begin{Vmatrix} 0 & -\sigma - r_2\cos\tau - q_2\sin\tau & r_1\cos\tau - q_1\sin\tau \\ & -r_2\sin\tau + q_2\cos\tau & -\sigma + r_1\sin\tau - q_1\cos\tau \\ 0 & & 0 \end{Vmatrix};$$

and $\omega = h/e$ is the frequency similar to the nutational frequency of an ordinary gyroscope.

One can show that $\omega = 1 + \omega_1$, where 1 and ω_1 are the natural frequencies of the gyroscope. Thus, unlike an ordinary gyroscope, ω is always greater than one and depends on the ratio of the moments of inertia of the rotor.

By replacing the variables $\bar{X} = e^{A\tau} V\bar{Y}$, where V is some nonspecial matrix intended to form a specific type of solution of system (3), the following equation is formed

$$\frac{d\bar{Y}}{d\tau} = \varepsilon D(\varepsilon;\ \tau)\bar{Y}; \quad D(\varepsilon;\ \tau) = V^{-1}e^{-A\tau}(B_1 + \varepsilon B_2)e^{A\tau}V;$$

$$V = \begin{Vmatrix} \omega & 0 & \\ 0 & \omega & 0 \\ 0 & 1 & \\ -1 & 0 & 1 \end{Vmatrix}. \tag{4}$$

Solution of equation (4) is represented, as is known [4], by the following power series:

$$\bar{Y}(\tau;\ \varepsilon) = F(\tau;\ \varepsilon)\,e^{k(\varepsilon)\tau},$$

$$F(\tau;\ \varepsilon) = 1 + \varepsilon F_1(\tau) + \varepsilon^2 F_2(\tau) + \ \ldots,$$

$$K(\varepsilon) = K_0 + \varepsilon K_1 + \varepsilon^2 K_2 + \ \ldots,$$

where the representative matrices K_1 and K_2 which determine the gyroscope characteristics are found by the expressions:

$$K_1 = [D]_{cp}; \quad K_2 = [DF_1 - F_1K_1]_{cp}; \quad F_1 = \int_0^{\tau} (D - K_1)\, d\tau_1. \tag{5}$$

As a result of averaging the initial equation (4) the representative matrix of the first approximation

$$K_1 = \begin{Vmatrix} -\varkappa_0 & -\delta_0 & & 0 \\ \delta_0 & -\varkappa_0 & & \\ & 0 & -\varkappa_{20} & \delta_0 \\ & & -\delta_0 & -\varkappa_{20} \end{Vmatrix},$$

$$\varkappa_0 = \frac{\varkappa}{e} - \frac{\varkappa_2}{\omega e}; \quad \varkappa_{20} = \frac{\varkappa_2}{\omega e}; \quad \delta_0 = \frac{\varepsilon\sigma}{\omega e},$$

in confirmation of known investigations represents the trajectory of motion of the gyroscope pole on the pattern plane of a logarithmic spiral with precession frequency $\varepsilon^2\sigma/\omega e$ and rate of vibrational damping $\varepsilon\chi_1/e$.

The following representative matrix of second approximation was found to analyze the effect of acceleration on the motion of the gyroscope by expression (5)

$$K_2 = \begin{Vmatrix} K_{11} & K_{12} & & 0 \\ -K_{12} & K_{11} & & \\ & 0 & K_{33} & K_{34} \\ & & K_{43} & K_{44} \end{Vmatrix},$$

where

$$K_{11} = \frac{\delta_0}{\omega}(\varkappa_0 - \varkappa_{20});$$

$$K_{12} = -\frac{\omega}{4(2\omega - 1)(\omega - 1)}(r_{10}^2 + r_{20}^2 + q_{10}^2 + q_{20}^2) + \frac{1}{\omega}(\varkappa_0\varkappa_{20} + \delta_0^2);$$

$$K_{33} = \frac{1}{2(\omega - 1)}(r_{10}r_{20} + q_{10}q_{20}) - \frac{\delta_0}{\omega}(\varkappa_0 - \varkappa_{20});$$

$$K_{44} = -\frac{1}{2(\omega - 1)}(r_{10}r_{20} + q_{10}q_{20}) - \frac{\delta_0}{\omega}(\varkappa_0 - \varkappa_{20});$$

$$K_{43} = \frac{1}{2(\omega - 1)}(r_{20}^2 + q_{20}^2) + \frac{1}{\omega}(\varkappa_0\varkappa_{20} + \delta_0^2);$$

$$K_{34} = -\frac{1}{2(\omega - 1)}(r_{10}^2 + q_{10}^2) - \frac{1}{\omega}(\varkappa_0\varkappa_{20} + \delta_0^2);$$

$$r_{10} = \frac{\varepsilon r_1}{\omega e}; \quad r_{20} = \frac{\varepsilon r_2}{\omega e}; \quad q_{10} = \frac{\varepsilon q_1}{\omega e}; \quad q_{20} = \frac{\varepsilon q_2}{\omega e}.$$

At $m_r z_r = m_r y_r + m_k y_k$ the conditions of stability by representative matrix $K(\varepsilon) = \varepsilon K_1 + \varepsilon^2 K_2$ with accuracy up to components with ε^3 may be represented in the following form:

-- in the direct precession mode ($\sigma > 0$)

$$\varkappa_2^2\Omega^2 + \sigma^2 > \frac{\sigma}{(\omega - \Omega)\,\omega e} r^2, \; r^2 = j^2 m_p^2 z_p^2;$$

-- in the inverse precession mode ($\sigma < 0$)

$$[\varkappa_1\omega + \varkappa_2(\omega - \Omega)]^2 + \sigma^2 > \frac{|\sigma|}{(2\omega - \Omega)(\omega - \Omega)\,e} r^2.$$

According to the derived conditions, the stability of the gyroscope depends on the residual detuning and on the moments of the internal and external friction forces. An appreciable decrease of the stability reserve is possible only at $\omega \rightarrow \Omega$, i.e., for gyroscopes whose rotor is close to the shape of a sphere (or of an elongated cylinder).

It should also be noted that in the presence of acceleration of the base the frequencies of precessional motion of the gyroscope assume the following values according to matrix $K(\varepsilon) = \varepsilon K_1 + \varepsilon^2 K_2$:

$$\Omega_1^2 = \varkappa_0^2 + \delta_0^2 + \frac{\omega\delta_0}{(2\omega - 1)(\omega - 1)} (r_{10}^2 + r_{20}^2);$$

$$\Omega_2^2 = \varkappa_{20}^2 + \delta_0^2 - \frac{\delta_0}{\omega - 1} (r_{10}^2 + r_{20}^2).$$

It is obvious that components with parameters r_1 and r_2 change the tuning of the gyroscope and when it is operating as a gyrostabilizer with display drive they lead to additional drift of the stabilizer, dependent on the ratio of the moments of inertia of the gyroscope rotor.

Thus, functions which characterize the stability of a dynamically tuned gyroscope in the presence of radially aligned linear acceleration of the base were found by using vector-matrix transformations and the method of averaging. It was also shown that linear acceleration leads to the occurrence of additional drift of the gyrostabilizer with display drive, as which gyroscopes of the considered type are usually employed.

BIBLIOGRAPHY

1. Brozgul', L. I. and Ye. L. Smirnov, "Vibratsionnyye giroskopy" [Vibrating Gyroscopes], Moscow, Mashinostroyeniye, 1970.

2. Rusanov, P. G., "The Stability of a Dynamically Tuned Gyroscope During Parametric Perturbation," IZV. VUZOV SSSR -- PRIBOROSTROYENIYE, No. 11, 1974.

3. Fedorchenko, A. M. and D. Od, "The Motion of a Heavy Asymmetrical Gyroscope With Vibrating Reference Point," UKRAINSKIY MATEMATICHESKIY ZHURNAL, No. 2, 1958.

4. Yakubovich, V. A. and V. M. Starzhinskiy, "Lineynyye differentsial'nyye uravneniya s periodicheskimi koeffitsiyentami i ikh prilozheniya" [Linear Differential Equations With Periodic Coefficients and Their Application], Moscow, Nauka, 1972.

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SELECTING THE SPACE OF STATES AND MEASUREMENTS IN PROBLEMS OF OPTIMUM CORRECTION OF INERTIAL NAVIGATION SYSTEMS

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[Article by V. A. Karakashev, S. G. Romanenko and A. S. Filippov, Leningrad]

[Text] The problem of selecting the space of states and formation of measurements in problems of optimum correction of inertial navigation systems is considered. As a result the feasibility of analog representation of errors of multiple navigation systems and the possibility of obtaining optimum linear estimates of the analog errors of an inertial coordinate system, simulated in inertial navigation systems, are shown.

Self-contained inertial navigation systems (INS) may operate with given accuracy only during a limited time interval since errors in data output on coordinates, linear velocity and angular orientation of the object, caused by instrument errors of the accelerometers and gyroscopes, increase in time. The accuracy of self-contained INS with prolonged operating time is mainly limited by the angular drift rates of the gyroscopes. Periodic or continuous correction of self-contained INS by data processed by the navigation systems (NS) contained in the navigation complex (NK) of the object is accomplished to reduce the errors.

Methods of optimum linear analysis, which permit more complete utilization of external information [1], have begun to be used extensively of late to improve the accuracy of corrected INS and consequently of the NK of the object. The necessary condition for implementing the methods is to describe the dynamics of the system and the measurements in vector-matrix form.

Let us consider the problem of selecting the space of states and measurements to find the optimum linear estimates of the errors of corrected INS.

The extensively employed classical form of describing INS errors provides compilation of differential error equations in simulation of some coordinate

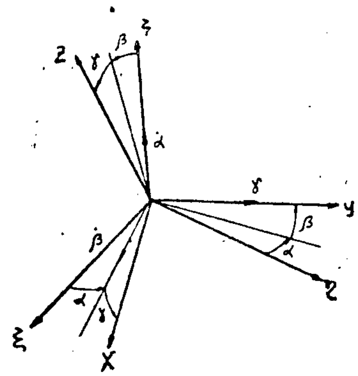

Figure 1

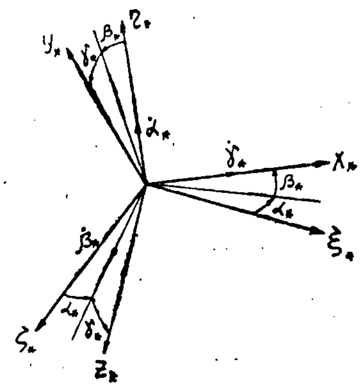

Figure 2

reference system which uncouples the sensing elements from the angular motions of the object and in developing the components of linear velocity, heading and coordinates of the moving object. However, the INS may be regarded as a device in which the selected inertial and ground coordinate systems and the vertical position of the object are simulated by means of mechanical analogs (stabilized platforms) and (or) analytical analogs (calculating devices). Based on this definition, errors in course K, latitude φ, longitude λ and the eastern V_ξ and northern V_η components of the linear velocity of the object may be represented as a function of errors β and γ of the vertical analog (Figure 1) and α_*, β_* and γ_* of the analog of the inertial coordinate system $\xi_* \eta_* \zeta_*$ (Figure 2) in the form [2]

$$\alpha = \frac{1}{\cos\varphi}(\tau_* + \gamma\sin\varphi);\ \ \Delta\varphi = \rho_* - \beta;\ \ \Delta\lambda = -\alpha_* + \frac{1}{\cos\varphi}(\tau_*\sin\varphi + \gamma);$$

$$\Delta V_\xi = R\left[\dot{\gamma} + (\dot{\tau}_*\sin\varphi - \dot{\alpha}\cos\varphi) + \dot{\varphi}\frac{1}{\cos\varphi}(\tau_* + \gamma\sin\varphi) - \dot{\lambda}(\rho_* - \beta)\sin\varphi\right], \tag{1}$$

$$\Delta V_\eta = R(\dot{\rho}_* - \dot{\beta}),$$

where

$$\tau_* = \beta_* \cos\lambda_* + \gamma_* \sin\lambda_*,$$
$$\rho_* = -\beta_* \sin\lambda_* + \gamma_* \cos\lambda_*.$$

The differential error equations of a self-contained INS, written in classical form, have the form

$$\begin{gathered}
\dot{\alpha} + \omega_\xi\gamma - \omega_\eta\beta = \delta_z + \Delta\varphi u \cos\varphi + \frac{\Delta V_\xi}{R}\,\mathrm{tg}\,\varphi + \Delta\varphi\frac{V_\xi}{R}\sec^2\varphi;\\
\dot{\beta} + \omega_\eta\alpha - \omega_\zeta\gamma = \delta_x - \frac{\Delta V_\eta}{R};\quad \dot{\gamma} - \omega_\xi\alpha + \omega_\zeta\beta = \delta_y + \frac{\Delta V_\xi}{R} - \Delta\varphi u \sin\varphi;\\
\Delta\dot{V}_\xi = a_\eta\alpha - (g + a_\zeta)\gamma + \Delta a_{B_\xi} + \delta a_x;\ \Delta\dot{V}_\eta = -a_\xi\alpha + (g + a_\zeta)\beta +\\
+ \Delta a_{B_\eta} + \delta a_y;\quad \Delta\dot{\varphi} = \frac{\Delta V_\eta}{R};\quad \Delta\dot{\lambda} = \frac{1}{\cos\varphi}\left(\frac{\Delta V_\xi}{R} + \Delta\varphi\dot{\lambda}\sin\varphi\right),
\end{gathered}\tag{2}$$

where u is the angular velocity of the earth's daily rotation; δ_x, δ_y and δ_z are the projections of the gyroscope drifts onto the axes xyz of the horizontal coordinate system $\xi\eta\zeta$, δa_x and δa_y are projections of the accelerometer errors on the analog axes xyz; and Δa_{B_ξ} and Δa_{B_η} are the errors in compensation for the eastern and northern components of the coriolis and translational accelerations.

The differential error equations of a self-contained INS is easily found in analog form from equations (2), having eliminated on the basis of equations (1) the variables α, $\Delta\varphi$ and $\Delta\lambda$:

$$\begin{gathered}
\dot{\beta} + \dot{\lambda}_*\tau_* = \delta_x - \frac{\Delta V_\eta}{R};\quad \dot{\gamma} + \frac{V_\eta}{R\cos\varphi}(\tau_* + \gamma\sin\varphi) + \rho_* u \sin\varphi + \frac{V_\xi}{R}\,\mathrm{tg}\,\varphi;\\
\beta = \delta_y + \frac{\Delta V_\xi}{R};\ \Delta\dot{V}_\xi = \frac{a_\eta}{\cos\varphi}(\tau_* + \gamma\sin\varphi) - (g + a_\zeta)\gamma + \Delta a_{B_\xi} + \delta a_x;\\
\Delta\dot{V}_\eta = -\frac{a_\xi}{\cos\varphi}(\tau_* + \gamma\sin\varphi) + (g + a_\zeta)\beta + \Delta a_{B_\eta} + \sigma a_y;\ \dot{\alpha}_* = \delta_{y_m};\\
\dot{\tau}_* - \dot{\lambda}_*\rho_* = \delta_{z_m};\quad \dot{\rho}_* + \dot{\lambda}_*\tau_* = \delta_{x_m};
\end{gathered}\tag{3}$$

where δ_{x_m}, δ_{y_m} and δ_{z_m} are the projections of the gyroscope drifts onto the analog axes $x_m y_m z_m$ of an equatorial coordinate system $\xi_m \eta_m \zeta_m$, bound to the meridian of the object, and $\lambda_* = ut + \lambda$.

It follows from equations (2) and (3) that the analog form of representing the differential error equations of self-contained INS has the following advantages compared to the classical form:

1) the errors of the analog of the inertial coordinate system (ISK) are not dependent on the errors of the vertical analog, whereas the errors of vertical analog are dependent on the errors of the ISK analog;

2) delineation of the effect of instrument errors of gyroscopes and accelerometers is possible (the errors of the ISK analog are determined only by the gyroscope drifts and not by the initial zero conditions).

The equations of the mathematical model of a transient dynamic system are usually represented in vector-matrix form [3]

$$\dot{X}(t) = F(t)X(t) + G(t)W(t), \tag{4}$$

where X(t) and W(t) are the vectors of states and noise of the system and F(t) and G(t) are the matrices of the dynamics and noise of the system.

Vector X_k of the classical space of states B_k, with regard to equations (2), may be written in the form

$$X_{\text{к}}^{\text{T}} = [\alpha,\ \beta,\ \gamma,\ \Delta V_{\xi},\ \Delta V_{\eta},\ \Delta\varphi,\ \Delta\lambda,\ \delta a_x,\ \delta a_y,\ \delta_x,\ \delta_y,\ \delta_z], \tag{5}$$

while vector X_A of the analog space of states B_A, according to equations (3), may be written in the form

$$X_{\text{A}}^{\text{T}} = [\beta,\ \gamma,\ \Delta V_{\xi},\ \Delta V_{\eta},\ \delta a_x,\ \delta a_y,\ \alpha_*,\ \tau_*,\ \rho_*,\ \delta_{x_m},\ \delta_{y_m},\ \delta_{z_m}], \tag{6}$$

where T is a symbol of transposition.

The variable states which characterize the instrument errors of accelerometers and gyroscopes are included in vectors X_k, X_A since usually δa_i (i = x, y) and δ_j (j = x, y, z) are not white noise.

With regard to equations (3), vector X_A and matrix $F_A(t)$ may be represented in the following form:

$$X_{\text{A}} = \begin{bmatrix} X_{\zeta} \\ X_* \end{bmatrix};\quad F_{\text{A}}(t) = \begin{bmatrix} F_{11}(t) & F_{12}(t) \\ 0 & F_{22}(t) \end{bmatrix}, \tag{7}$$

where

$$\begin{aligned} X_{\zeta}^{\text{T}} &= [\beta,\ \gamma,\ \Delta V_{\xi},\ \Delta V_{\eta},\ \delta a_x,\ \delta a_y]; \\ X_*^{\text{T}} &= [\alpha_*,\ \tau_*,\ \rho_*,\ \delta_{x_m},\ \delta_{y_m}^{*},\ \delta_{z_m}]; \end{aligned} \tag{8}$$

0 is a zero matrix.

The presence of a xero matrix in $F_A(t)$ indicates that an invariant subspace B_*, formed by the variables of vector X_* like the basic vectors, exists in the analog space of states B_A. It is obvious from equations (2) that this invariant subspace may not be determined in the classical space of states B_k.

Since vector X_* and matrix $F_{22}(t)$ may be represented in the form

$$X_* = \begin{bmatrix} X_m \\ X_\delta \end{bmatrix}; \; F_{22}(t) = \begin{bmatrix} F_m(t) & F_{m\delta}(t) \\ 0 & F_\delta(t) \end{bmatrix}, \tag{9}$$

the invariant subspace B_δ, stretched to variables δ_{jm}, exists inside the invariant subspace B_*. It follows from equation (2) and expression (5) that the invariant subspace B_* also exists in the classical space of states B_k. Consequently, the analog space of states permits more effective solution of the problems of optimizing INS since natural separation of the natural frequencies of errors of the vertical analogs and ISK occurs in this case.

Let us consider the problem of formation of measurements in corrected INS. The model of measurements is usually represented in vector-matrix form in the form [3]

$$Z(t) = H(t)X(t) + V(t), \tag{10}$$

where Z(t) and V(t) are the measurement vectors and measurement noise and H(t) is the measurement matrix.

Since the navigation parameters of the object are worked out by NK systems with errors, the following measurements may be found upon comparison of information of the same type from the INS and NS:

$$\begin{gathered} Z_1 = K_c - K_в = \alpha - \alpha_в, \quad Z_2 = \varphi_c - \varphi_в = \Delta\varphi - \Delta\varphi_в, \\ Z_3 = \lambda_c - \lambda_в = \Delta\lambda - \Delta\lambda_в, \quad Z_4 = V_{\xi_c} - V_{\xi_в} = \Delta V_\xi - \Delta V_{\xi_в}, \\ Z_5 = V_{\eta_c} - V_{\eta_в} = \Delta V_\eta - \Delta V_{\eta_в}. \end{gathered} \tag{11}$$

Measurements Z_k (k = 1, 2, 3, 4, 5), written in the form of (11), do not reveal the internal structure of the INS and NS errors, which makes it difficult to use them to analyze and synthesize the NK of the objects. However, all the navigation systems may be separated into two groups: the first group includes systems in which the navigation parameters of the object are worked out by using mechanical or analytical analogs of the vertical and the second includes systems in which the position vertical is not simulated.

Errors of the first group of NS in developing K, φ and λ of an object may be represented by analogy with equations (1) in the form [4]

$$\alpha_в = \frac{1}{\cos\varphi}(\tau_{*_в} + \gamma_в \sin\varphi), \; \Delta\varphi_в = \rho_{*_в} - \beta_в, \; \Delta\lambda_в = -\alpha_{*_в} + \frac{1}{\cos\varphi}(\tau_{*_в}\sin\varphi + \gamma_в), \tag{12}$$

where β_V, γ_V and α_{*_V}, τ_{*_V} and ρ_{*_V} are the errors of the analogs of the vertical and of the inertial (or ground) coordinate system, respectively, simulated in the NS.

It follows from the introduced classification that NS related to the second group may essentially not develop information about the heading of the object, while their errors may possibly be represented only conditionally in the form of (12).

Thus, having used information about K, φ and λ from the INS and NS of the first group, one can make the following measurements:

$$\begin{aligned} Z_1 &= K_c - K_B = \alpha - \alpha_B = \frac{1}{\cos\varphi}\{\tau_* - [\tau_{*_B} - (\gamma - \gamma_B)\sin\varphi]\}, \\ Z_2 &= \varphi_c - \varphi_B = \Delta\varphi - \Delta\varphi_B = \rho_* - [\rho_{*_B} + (\beta - \beta_B)], \\ Z_3 &= \lambda_c - \lambda_B = \Delta\lambda - \Delta\lambda_B = -\alpha_* + \left\{\alpha_{*_B} + \frac{1}{\cos\varphi}[(\tau_* - \tau_{*_B})\sin\varphi + (\gamma - \gamma_B)]\right\}, \end{aligned} \tag{13}$$

and having used information about φ and λ from the INS and NS of the second group, one can make the following measurements:

$$\begin{aligned} Z_2 &= \varphi_c - \varphi_B = \Delta\varphi - \Delta\varphi_B = (\rho_* - \beta) - \Delta\varphi_B, \\ Z_3 &= \lambda_c - \lambda_B = \Delta\lambda - \Delta\lambda_B = \left[-\alpha_* + \frac{1}{\cos\varphi}(\tau_*\sin\varphi + \gamma)\right] - \Delta\lambda_B. \end{aligned} \tag{14}$$

It follows from (13) and (14) that the variable vectors X_*, not dependent on the variables of vector X_C in the model of the system, are related to the latter by measurements.

If the INS vertical is used in the NS, i.e., if the approximate equations are provided

$$\beta \cong \beta_B, \quad \gamma \cong \gamma_B, \tag{15}$$

then measurements (13) acquire the form

$$\begin{aligned} Z_1 &= (\tau_* - \tau_{*_B})\sec\varphi, \\ Z_2 &= \rho_* - \rho_{*_B}, \\ Z_3 &= -(\alpha_* - \alpha_{*_B}) + (\tau_* - \tau_{*_B})\operatorname{tg}\varphi. \end{aligned} \tag{16}$$

Consequently, introduction of an INS vertical in a NS permits one to measure only the errors of the ISK analog and to obtain the optimum linear estimate of vector X_*. In this case, in view of the natural separation of the natural

frequencies of the INS, the interval of measurement discreteness may be increased significantly since precision gyroscopes with long correction time (for example, gyroscopes with electrostatic suspension of the rotor) do not place significant restrictions on the discreteness of the measurements.

The feasibility of analog representation of errors of multiple navigation systems and formation of measurements with an INS vertical may be illustrated on an example of reducing requirements to the airborne digital computer which realizes the algorithm of optimum Kalman filtration for the following three variants:

1. Analysis $\hat{X}_*$ of vector X_* contained in vector X_A is sought by using a filter 12 of the order of measurements (13);

2. $\hat{X}_*$ is sought by using filter 6 on the order of measurements (16);

3. $\hat{X}_*$ is sought by analyses of vector X_δ, found in filter 3 on the order of sequential measurements (16) and by the known estimate of vector $\tilde{X}_m(0)$ at initial moment of time t = 0.

(1) Варианты	(2) Емкость памяти, %	(3) Время счета цикла, %
1	100	100
2	31	2
3	14	0,4

KEY:

1. Variants
2. Storage capacity, percent
3. Counting time of cycle, percent

Selecting the interval of measurement discreteness is determined in the first variant by the vibrational frequency with period of M. Shuler and in the second and third variant by the vibrational frequency with period close to diurnal.

The results of calculations made on the basis of article [5] are presented in the table.

It must be noted that in the considered example a reduction of requirements on the computer is achieved without simplification of both the model of the system and of the algorithm of optimum linear analysis.

BIBLIOGRAPHY

1. Gelb, A. and A. Sutherland, "Software Advances in Aided Inertial Navigation Systems," NAVIGATION JOURNAL OF THE INSTITUTE OF NAVIGATION, Vol. 17, No. 4, 1970-1971.

2. Karakashev, V. A., "Generalized Error Equations of Inertial Navigation Systems," IZV. VUZOV SSSR -- PRIBOROSTROYENIYE, No. 3, 1973.

3. Kalman, R. E. and R. S. Busy, "New Results in Linear Filtering and Prediction Theory" -- I, BASIC ENGINEERING, Vol. 83, 1961.

4. Karakashev, V. A. and V. A. Udalov, "Kinematic Error Equations of Astronavigation Systems," IZV. VUZOV SSSR -- PRIBOROSTROYENIYE, No. 12, 1974.

5. Mendel, J., "Computational Requirements for a Discrete Kalman Filter," IEEE TRANSACTIONS ON AUTOMATIC CONTROL, Vol. AC-16, No. 6, December 1971.

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GEOPHYSICS, ASTRONOMY AND SPACE

ROCKET LAUNCHING FACILITIES AT BAYKONUR DESCRIBED

Moscow ZEMLYA I VSELENNAYA in Russian No 1, 1978 pp 64-71

[Article by Professor B. P. Vladimirov]

[Text] A great flotilla of spaceships and vehicles has penetrated onto space trajectories, close and distant, circumterrestrial and lunar, to Venus and Mars, from the space harbor -- the Baykonur cosmodrome. Baykonur is known to all, or almost all, who live on our planet. It is entering into the annals of history as a superlative creation of man in the 20th century.

When work developed on the creation of a powerful space rocket, the outlines of the future cosmodrome were defined on drawings and blueprints. Little more than a year had passed and the ideas of designers were embodied in machines, mechanisms, instruments and vehicles. They were embodied in metal and concrete.

A cosmodrome is a complex, multiaspect installation which spreads over an extensive area. It is a combination of unique assemblies, apparatuses, automatic systems and engineering structures. Its creators must solve a great number of problems ranging from the transportation of individual components of the rocket and its assembly to theoretical and experimental investigations of thermal, gas-dynamical and acoustical processes transpiring during the time of rocket launching. A cosmodrome cannot be taken in by a single glance and cannot be encompassed by a single motion picture frame. It is difficult to see it entirely even from a helicopter. A dense network of railroad tracks and roads connects all the cosmodrome services into a single whole.

Cosmodrome Services

The principal parts of the cosmodrome are the launching pads and the central link of each pad is the launching structure. Here are gathered together all the "strands" involved in the preparation of the space rocket for launching. It is from this point that space trajectories begin.

Powerful columns support the main part of the launching structure -- a gantry crane with a 16-m span for the "tail" of the rocket. Beneath it there is a channel for carrying away gases, through which flow the

combustion products from the engines. The launching system is mounted on the gantry crane. In the launching and other structures there are fueling systems and systems for the thermostating the fuel, a compressor system, receiver systems for compressed gases, containers for storing the fuel, equipment for systems for controlling the preparation of the rocket for launching and for the actual launching.

Beyond the channel for carrying off the gases is the command point bunker (blockhouse). It is connected by cables with all the operational services at the cosmodrome, observation and command-measuring points. A little more distant is the assembly-test building. A railroad track joins the assembly-test building and the launching pad. The spaceships travel along the track to the latter point, from which their journey into the universe begins.

The principal assembly of the launching complex is the launching system. It has a rather unusual appearance due to the rather unusual configuration of the carrier-rocket. The design of the rocket is a packet with a transverse division of stages resembling the well-known Russian troika. There are five units in the "harness" of the first and second stages. The central unit -- "core" -- is the first and simultaneously the second stage, and symmetrically joined to it in a circle are the four lateral units of the first stage.

These lateral units have a conical configuration and seemingly support the central unit at a distance of approximately 20 m (the total length of the carrier-rocket with the spaceship is about 50 m) from the rocket base. Beyond the "top" of the side units the rocket is suspended in the launching system, penetrating approximately 7 m into the opening of the launching structure. All its weight rests on four support points.

Such a configuration of the rocket has radically changed the traditional ideas about its launching. Usually a rocket rests with its end in a launching apparatus and in rising immediately leaves behind its "tail" all the elements of the launching apparatus. In accordance with this scheme the launching system must support the rocket up to the time when its engines enter the main thrust regime and as soon as the rocket roars upward in several seconds it has a free path into the sky.

As a rule, in the initial segments of motion the rocket still does not have sufficient stabilization and a strong wind or nonuniform engine thrust can deflect it from a strictly vertical ascent. Therefore, for each type of rocket there are limits for its safe launching zone. The rocket must have a "corridor" through which it can be safely launched. This means that all the elements of the launching structure must be situated beyond the limits of this corridor and the supports on which the rocket is suspended before the launching must be swung free when its tail part passes by them. Similar restrictions determined the diameter of the opening in the launching structure for the "tail" of the rocket and the internal diameter of the annular base of the launching system.

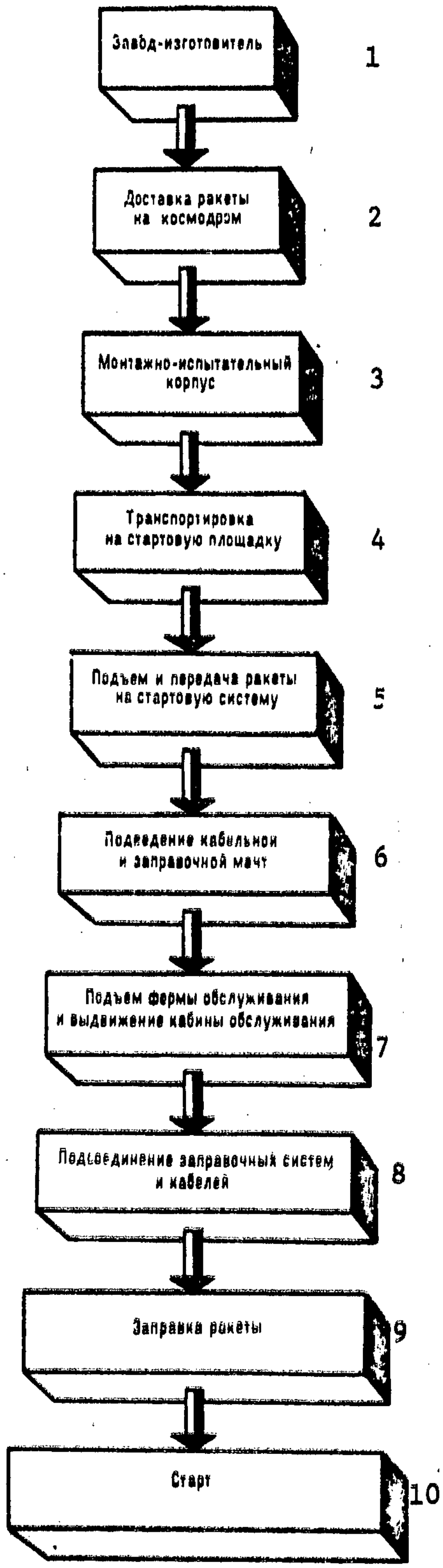
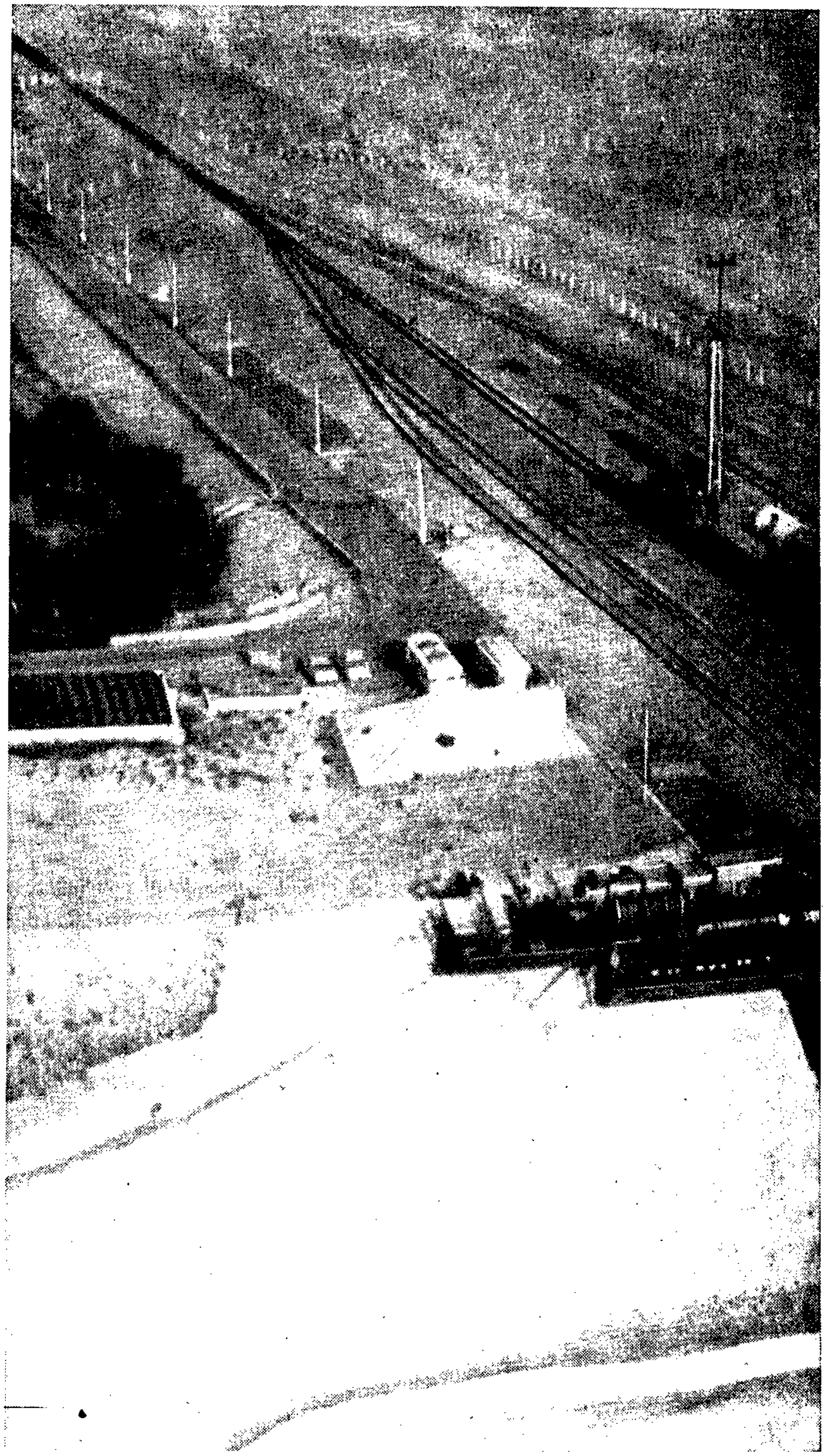
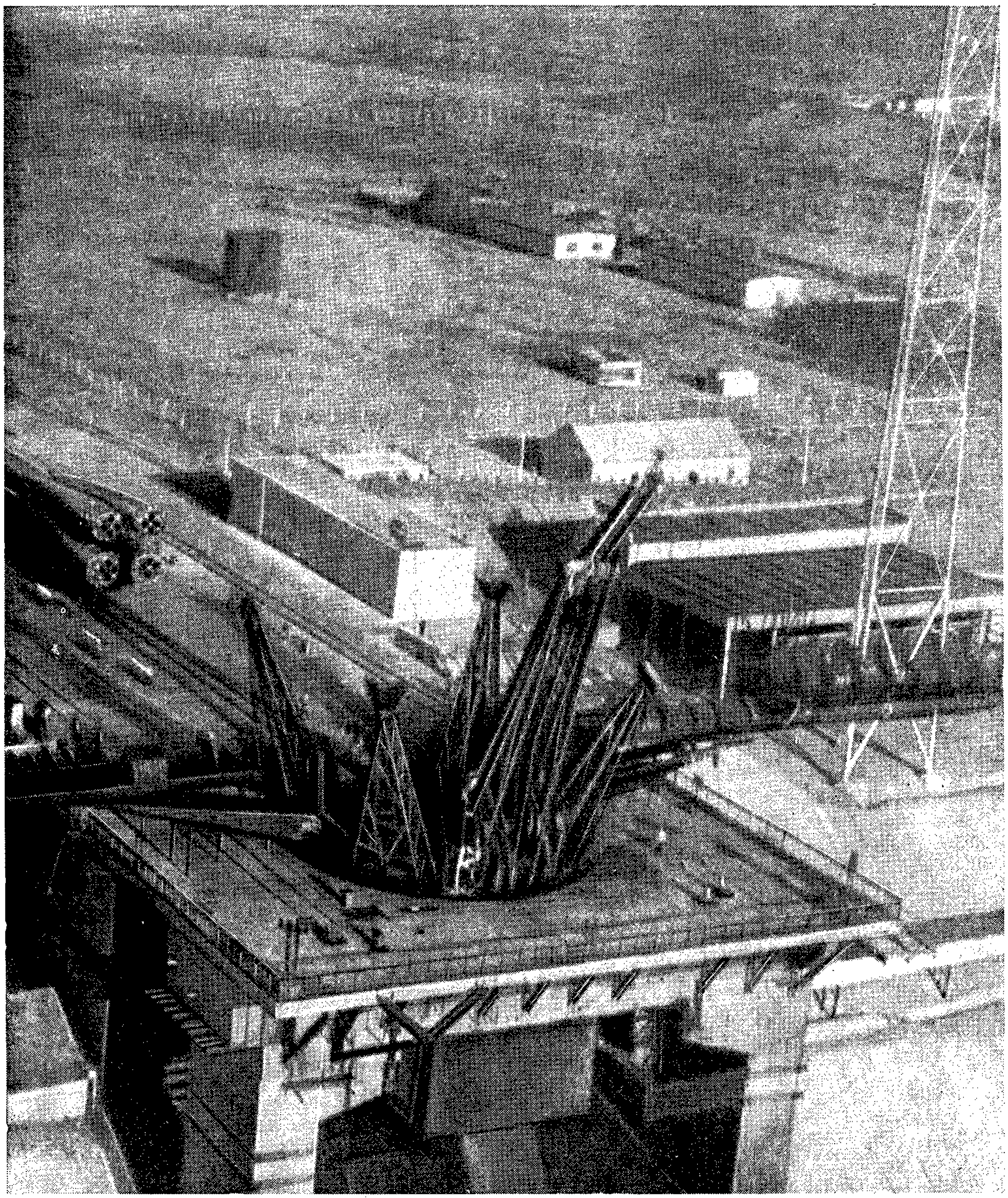


Diagram of movement and preparation of rocket for launching from time of construction to launching

1. Construction plant
2. Rocket delivery to cosmodrome
3. Assembly-test building
4. Transport to launching pad
5. Raising and linking of rocket to launching system
6. Bringing up cable and fueling masts
7. Raising of servicing beams and extension of servicing cabin
8. Connection of fueling systems and cables
9. Rocket fueling
10. Launching



Launching site



The supporting structure of the launching system looks as follows: in the plane of the suspension supports the body of the rocket is freely held by a supporting structure consisting of four supporting beams which are attached to the base of the launching system by joints. When this supporting structure is closed, a rigid structure is formed from these four individual parts and this closed structure reliably holds the multi-ton rocket. Outwardly the structure resembles a truncated pyramid, within which the rocket is suspended. By its weight it holds the pyramid in a closed position. The rocket, freely suspended in the launching system, can sway like a pendulum under the influence of the wind or the nonuniform thrust of the engines. Therefore, inadmissible overloads can arise in the supporting elements of the rocket and its initial spatial orientation is impaired. In order to avoid this, the rocket is fixed at the base at four points near the stabilizers. The structural elements to which the rocket is attached by joints, like the supporting elements of the pyramid, are disconnected from the rocket during its initial motion and under the influence of their own weight are moved to one side. The pyramid supports the rocket up to the time that its engines attain an adequate thrust capable of lifting the rocket and imparting to it a reliable initial motion. As soon as the rocket begins its motion the pyramid opens and the four supporting beams which make it up in several seconds withdraw beyond the limits of the starting corridor, freeing the way for the rocket.

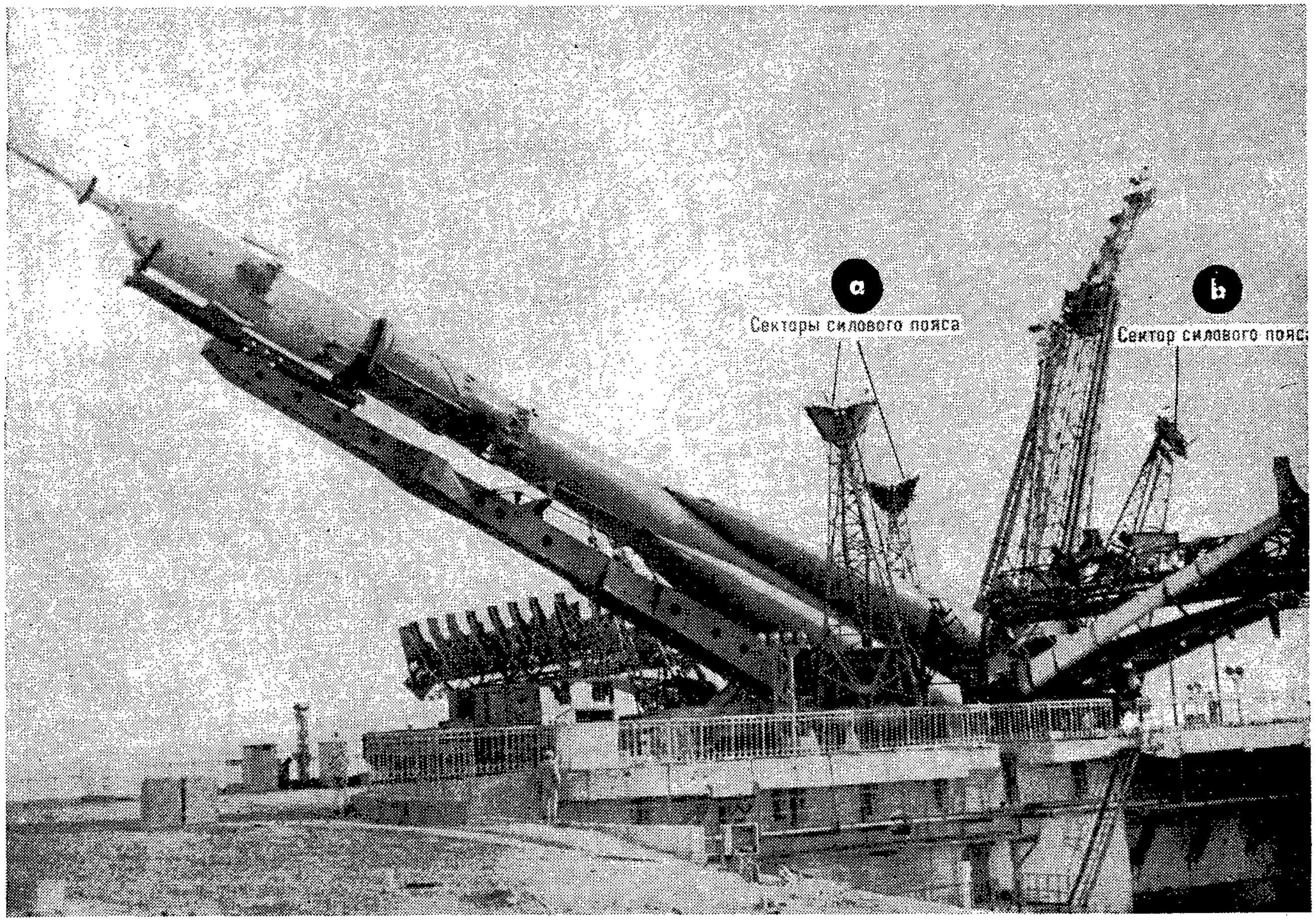
During the launching of space rockets it is easy to see how the supporting beams are swept away from the rocket and how in clouds of fire and smoke it is slowly lifted off from the ground. When the first tests at the cosmodrome were carried out with opening up of the pyramid it was called the "tulip."

They say that the simpler a structure is, the more reliable it is. The launching system has precisely such qualities. Many different ships and satellites have been created during the two decades of the space era, but the "tulip" has reliably ensured and continues to ensure that spacecraft will depart on their space journeys.

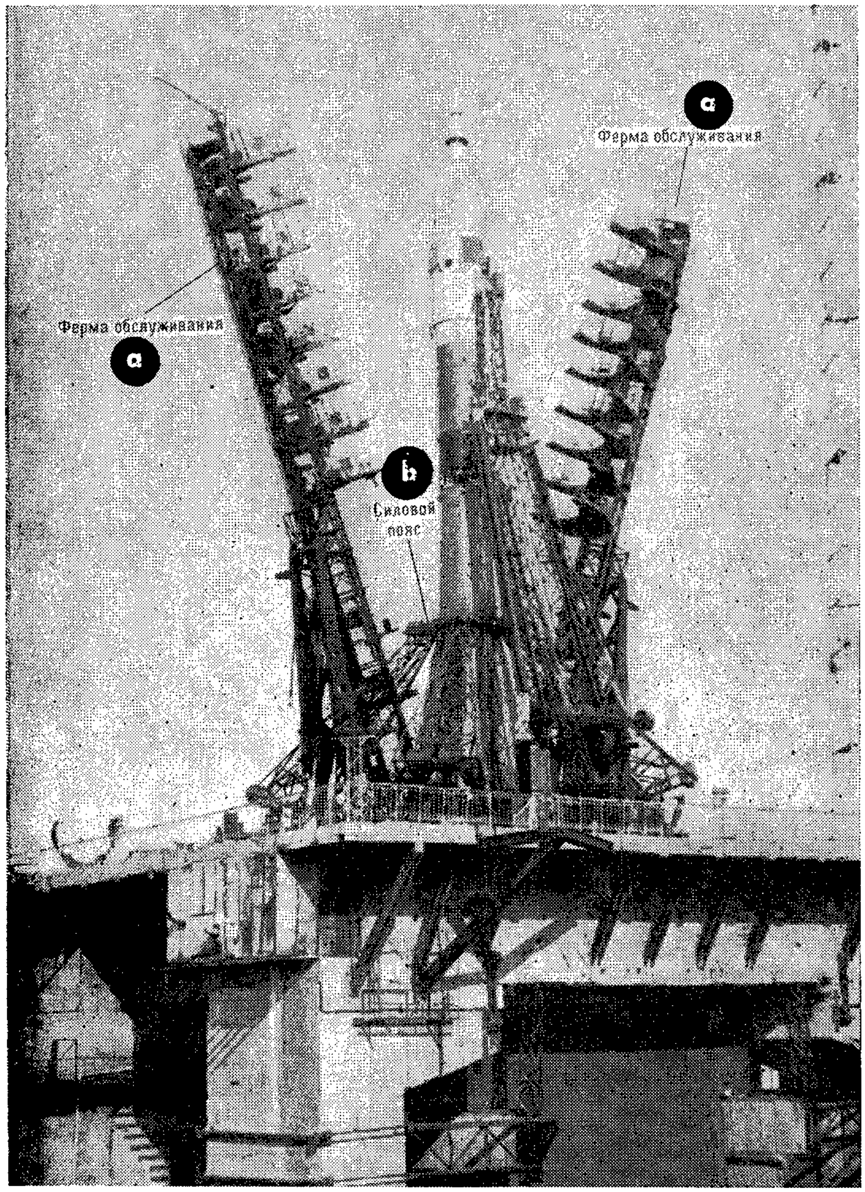
The launching system is outfitted with cable and fueling masts. Their very names define their purposes. Through the first of these masts pass the cables for supplying the carrier-rocket with electric power before the launching, whereas the other carries lines for delivery of fuel and telemetric cables to space objects. When one sees motion pictures of a rocket launching, you see that several seconds before the launching the masts are swiftly drawn away from the side of the rocket.

Prelaunching Laboratory at Cosmodrome

The servicing facilities are of particular importance in the launching complex. They ensure that servicing personnel will have access to the places of joining of the fueling systems, electric and pneumatic plugs and connections, and to the rocket itself, as well as ensuring delivery of instruments and devices to different heights. The last checking of the rocket before launching begins from the servicing facilities (servicing beams and cabin).

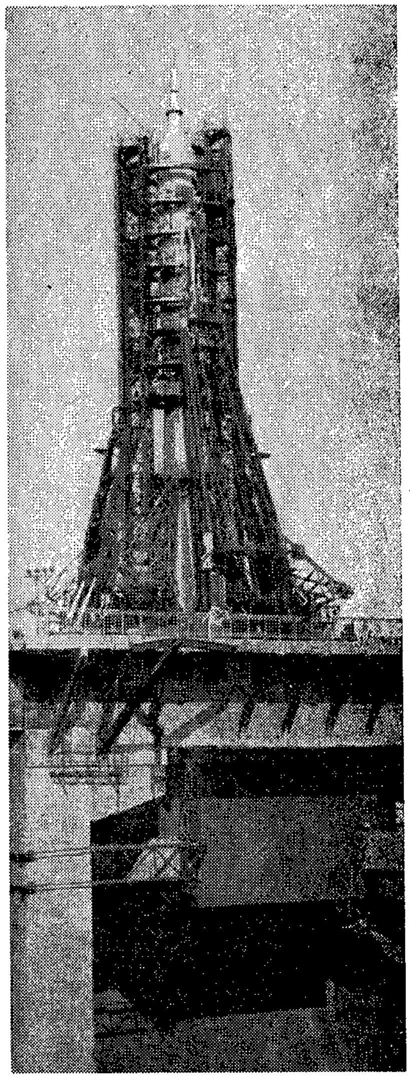


Putting the rocket into a vertical position. The supporting elements of the launching system, masts and servicing beams are withdrawn. a-b) Four elements of "pyramid" in opened form.



The figure shows the rocket mounted in the launching system. The positioning of the cable and fueling masts can be seen. The servicing beams are marked. The lower part of the photograph shows the deflector of the launching structure. a) servicing beam (tower); b) "pyramid"

The servicing beam (towers) consists of two columns with a height almost equivalent to the rocket, attached to the base of the launching system by joints. In a working position a sort of gantry is formed with platforms at different levels, within which the rocket is situated. The platforms freely encircle the rocket and make it possible to service it from all sides. Some platforms have a closed space where microclimatic zones



Rocket during the last period of preparation for launching. Visible are the deflector of the launching structure and the channel for carrying off gases.

are created for operations when there are great temperature drops. From the uppermost platform the cosmonauts take their places in the ship. Before the rocket launching the gantry parts and each half of the tower is lowered to a horizontal position, moving in different directions.

Servicing cabin. This is an enormous platform which spans the entire gap in the launching structure below the rocket. Beneath the rocket it creates a suspended working place for its servicing. The multilevel extensible platforms of the cabin ensure free access to the numerous places where the tail part of the rocket is serviced.

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Last Preparations

The preparation of the rocket for launching begins with the transporting of its elements and spaceships and apparatus in special railroad cars from the manufacturing plants. At the cosmodrome they are delivered to the assembly-test building. Here is the realm of cleanliness. This is emphasized by the white gowns of the specialists and technicians.

The assembly-test building of the cosmodrome, where the rocket acquires its final form, is familiar to us from the screens of television screens, still photographs, and motion pictures. It is supplied with different equipment, monitoring and testing apparatus and instrumentation ensuring the thorough and final checking of the "viability" of the rocket and the spaceship on the impending flight.

Finally, all the rocket components have been checked. The last operation is performed: the spaceship is joined to the rocket. After this the rocket-space system is tested as a whole and the rocket and the ship are ready for a call to the launching pad.

Powerful bridge cranes lay them on the erector. The assembly-test building is opened wide and the erector is slowly directed to the launching pad. It seems like a fantastic ship is floating through the steppe expanses. And on the pad everything is now ready for reception of the rocket and the ship. The launching system is reduced to its initial position: the supporting beams are moved away, the cable and fueling masts are withdrawn and the columns of the servicing beams are lowered.

The erector covers the last meters along a calibrated track. Self-propelled bogies pull it along with millimeter accuracy. The frame -- the base of the erector -- is suspended on jacks and is rigidly attached to the foundation. Then comes the raising. A button for controlling the pumping station of the hydraulic system is pushed on the erector control panel. And now the gigantic silvery-white body of the rocket has floated upward. After a few minutes it is already standing vertically in the gap of the launching structure. It is really necessary to have steel "muscles" in order to hold it in such a position with an accuracy to a millimeter. The enormous erector performs this operation with the accuracy of a jeweler.

Power is fed to the launching system. The pumping apparatus for raising the supporting beams is switched on. And the four beams are simultaneously raised, the sections approaching the rocket. The tracking systems rigorously synchronize their motion. The "pyramid" embraces the body of the rocket, the "petals of the tulip" are closed. Now it is possible to link the rocket and ship with the erector to the launching system. The communications between the rocket and the erector boom are disconnected. The boom is lowered to its initial position and the erector is returned to the assembly-test building.

After the final attachment of the rocket system the columns of the servicing beams are raised. The cable and fueling masts are brought up to the side of the rocket. The sleeves of the fueling systems are connected. The pneumatic components of the gas communication lines and the plugs of the cable lines are joined.

The "verticality" of the rocket is checked. If any deviations are discovered, the stabilization system is switched on, which sets the thousand-ton structure in the necessary position with an accuracy to several seconds of angle. This is attributable to the fact that the launching system seems to float in hydraulic suspensions.

A very serious stage in preparation of the rocket for launching is its supplying with fuel and compressed gases. From this moment everything conforms to a rigorous technological sequence. The main role is played by the logic circuit, which is the basis of the system for the control of fueling. It rigorously "sees to it" that each machine, assembly, mechanism and instrument precisely performs its functions.

The center for the control of fueling is concentrated in the bunker, where one finds the control, monitoring and signaling panels. The blinking of the monitoring lights signals rhythmic operation of the fueling systems. The fueling process is seen from illuminated mnemonic displays. Powerful pumping plants along the main lines feed the fuel at a high speed from the storage tanks to the launching structure. From there, along individual secondary lines, connected to the side of the rocket, the fuel is fed into its tanks. At the same time the rocket is supplied with compressed gases.

Measuring instruments, situated at different places along the fueling lines, rigorously monitor the parameters of the supplied components: temperature and pressure at different points in the fuel lines, rate of delivery, level and volume.

Before the Launching

The rocket fueling has ended. At the launching pad the last operations are being performed for preparing it for launching. The fueling lines are disconnected from the rocket, the servicing cabin is withdrawn into its niche and the columns of the servicing beams are lowered into a horizontal position.

The 15-minute countdown begins. The servicing personnel abandon the launching pad. Approximately five minutes prior to the launching the first command is fed and this, like an echo, is carried by internal communication lines through the cosmodrome:

"Ready for launching!"

At the central monitoring and control panel in the bunker a switch is turned to the "Launch" position. An automated cycle of prelaunching and launching operations begins. A second command is fed:

"First cycle!"

The telemetric system "interrogates" the thousands of sensors mounted in all corners of the rocket.

"Scavenge!"

The channels in the system for supplying the fuel and the engines are scavenged with nitrogen. Approximately a minute prior to launching a command is fed:

"Drainage switch!"

Aboard the rocket all the drainage devices are closed. The feeding of the fuel tanks from the ground fueling systems ends.

"Launch!"

But this is still not the rocket launching, but only total readiness for it. From this instant the on-board systems for rocket control are switched on.

"Second cycle!"

The state of all on-board systems is registered, but now in an autonomous operating regime, the last check-out.

"Contact earth-ship!"

On the screens of the television sets it can be seen how the fueling and then the cable mast are swept away. The on-board systems of the spaceship and the rocket are shifted to autonomous control and an on-board power supply. The time countdown signals can be heard in the microphones and loudspeakers. The last seconds before launching!

The control panel timing mechanism is switched on. From this moment the launching time corresponds to the computed time with an accuracy to hundredths of a second.

"Ignition!" is the command heard through the communications systems.

An enormous flame flares up at the base of the rocket. An avalanche of fire fills the gap in the launching structure. It thunders into the channel carrying off the gases. An unbelievable noise grows and grows: the engine has begun to operate.

Finally, the most exciting command: "Launching!" An instant and the launching system, as if sensing that the rocket has gained sufficient force in order to burst into space, easily looses its embrace, allowing the rocket to freely penetrate into space.

Shrouded in clouds of smoke, the rocket is detached from the earth. Twenty million horsepower carry it into space. It moves more and more rapidly. The thundering of the engines dies down. The luminescent point disappears in the sky.

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THE NORTH POLAR SPUR--REMNANT OF A SUPERNOVA EXPLOSION

Moscow PRIRODA in Russian No 12, 1977 pp 17-19

[Article by Ya. M. Khazan, Siberian Institute of Geomagnetism, the Ionosphere and Radio Propagation, USSR Academy of Sciences, Irkutsk]

[Text] The North Polar Spur (NPS) is a radio object in the northern hemisphere of the galaxy which is well known to astronomers. At radio frequencies it appears as a huge, very clearly defined arch, protruding from the galactic plane and rising to a considerable latitude. Radio observations made a few years ago using the Dwingeloo (Holland) radiotelescope indicate that the radiation from the NPS is rather strongly polarized. It follows that it is of a synchrotronous nature: that is, it is produced by the movement of high-energy electrons in a magnetic field of a fairly ordered structure.

This pattern is typical of remnants of supernova explosions. We know[1] that in these explosions a gaseous shell is ejected from the star. The ejected gas moves at a high velocity (usually 5,000-10,000 kilometers per second) and sweeps up interstellar matter, as well as the interstellar magnetic field and cosmic rays. As a result an expanding shell structure forms with an increased concentration of gas and relativistic particles and an intensified magnetic field. Under ideal conditions (i.e. if the ejection of gas were to take place in a spherically symmetrical manner and if the conditions in interstellar space near the supernova were the same in all directions) the shell would preserve its spherical shape during expansion. The highest intensity of radio emissions should be observed in directions tangent to the spherical shell, so that a clearly defined ring would be visible on the radio map of the sky. When the interstellar gas is compressed, the magnetic field of the shell orients itself primarily along the shell, and accordingly it can be expected that the radio emission from the ring will be polarized. The fact that the actual shape of the NPS departs from true sphericity poses no difficulty: the somewhat divergent form and even the fact that we see a radio-emitting arch rather than a closed structure are easy to explain in terms of the nonuniformity of the propagation conditions in different parts of the shell.

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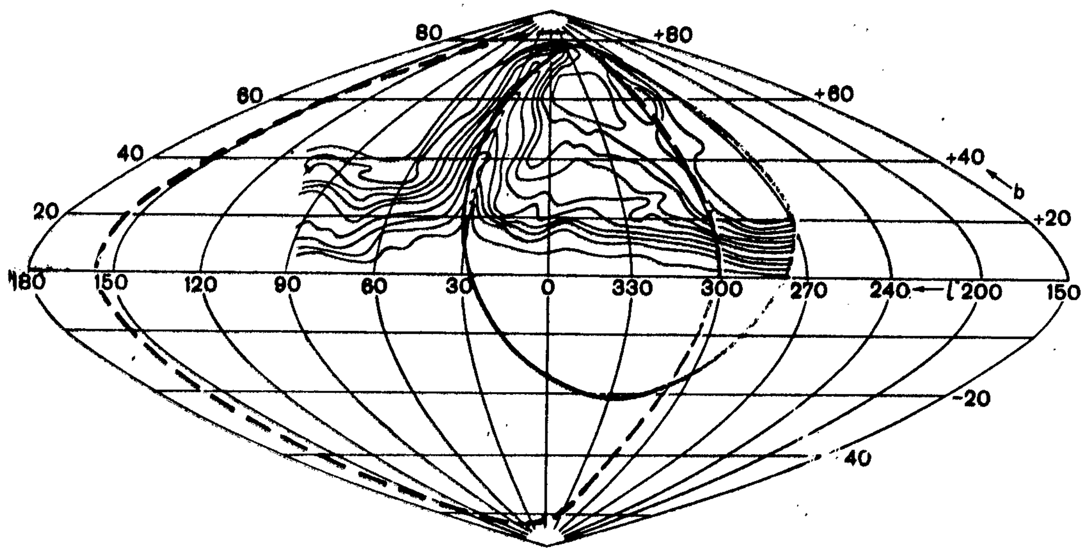
1. The physical processes that occur in supernova explosions are discussed in detail in I. S. Shklovskiy's book SVERKHNOVYYE ZVEZDY [SUPERNOVAS] (Moscow, 1976).



Radio Map of the Sky (150 MHz). The coordinate system is chosen to make the galactic equator coincide with the position of the galactic plane (l and b are galactic longitude and latitude respectively). The fine lines are the lines of constant intensity of radio emissions. The loops formed by these lines in the northern hemisphere in the vicinity of longitude 30° represent the clearly defined arch of the NPS. The solid line shows the presumed position of the shell of the supernova whose explosion may have led to the formation of the NPS. The Japanese X-ray detector was carried by a rocket and returned to earth with it. The orientation of the detector during flight described the figure shown by the dotted line.

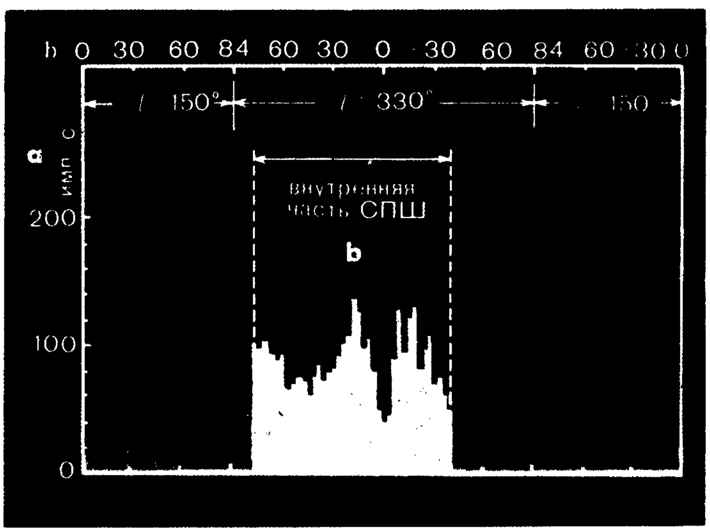
This explanation of the nature of the NPS has undergone much analysis, and might possibly have achieved general acceptance quickly if it were not for its immense angular dimensions: it is much larger than any of the objects which are definitely known to be remains of supernova explosions. We recall that the angular diameter of the NPS is 100-120°, while typical angular dimensions for even the largest known supernova remnants do not exceed several degrees.

In addition, the optical emissions from the gas and relativistic particles enclosed in the shell are usually observable in supernova remnants. No such radiation has been observed in the case of the NPS. Finally, the diameter of the NPS amounts to at least 200 parsecs, considerably surpassing the typical diameters of 20-50 parsecs for old supernova remnants.

The course of expansion of supernova remnants is determined primarily by the initial energy of ejection of the shell and the density of interstellar gas in the area in which the burst takes place. If we assume that the gas concentration is about average, the huge diameter of the NPS can only be explained by an improbably large supernova burst. Thus, the kinetic energy of the ejected gas would have to reach 10^{52}-10^{53} ergs, which is significantly greater than the usual energy release of 10^{49}-10^{52} ergs for supernovas. If on the other hand we try to explain the origin of the NPS in terms of the explosion of a less power-

ful supernova, we must assume that the interstellar medium in the area where the burst took place must be extremely rarefied. The gas concentration under this hypothesis would have to be of the order of 0.01 cm^{-3}, while the typical gas concentration in the galactic disk is 0.0-1 cm^{-3}.

Thus in models treating the NPS as the remnant of a supernova explosion, either the parameters of the star itself or the conditions in the interstellar gas are not quite the usual ones. This circumstance has stimulated the search for other possibilities. The choice between various models can only be made on the basis of observational tests of predictions. Such predictions for the explosion model were made by I. S. Shklovskiy and Ye. K. Sheffer in 1971. They showed that if the NPS was the remnant of a supernova the shell should contain hot gas, heated by the shock wave from the explosion. The temperature of this gas might reach millions of degrees, in which case its existence cound be detected through observations in the X-ray range. X-ray radiation would not arise in any of the other models, and accordingly observations in the X-ray range are very important in explaining the nature of the NPS.



Change in X-ray intensity along the trajectory described by the orientation of the Japanese group's detector. (range of photon energies 0.4-0.8 keV).

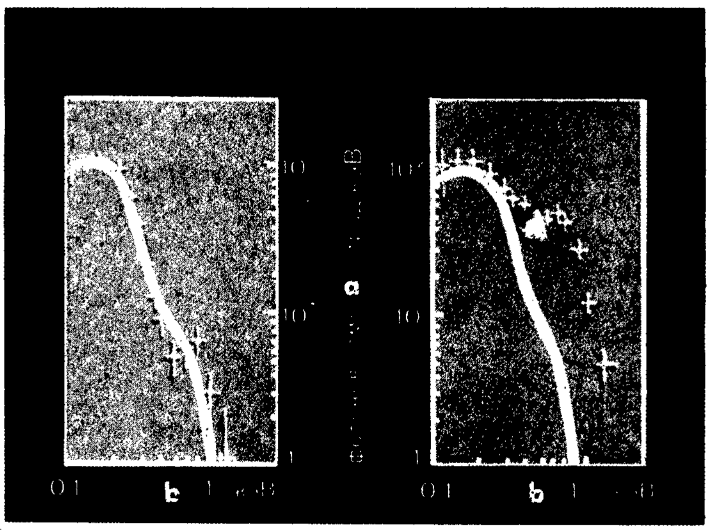
Key: a: pulses/second
b: interior of NPS

Such observations have been made frequently during the 70's, but the most reliable results were obtained recently by an American group led by G. Friedman and by the Japanese group of S. Hayakawa.

The diagrams show the areas of sky which were viewed by the Japanese group's detector and the dependance on galactic width of the number of photons recorded per unit time in one of the detector's energy ranges. The increased count while the detector's field of vision was crossing the NPS is quite clearly visible. Spectral measurements made by Hayakawa's group are even more interesting. One of the spectra shown is a typical X-ray spectrum in a direction "past" the NPS, while the other is a spectrum taken in the direction of the NPS. The additional radiation above the background intensity in the graph on the right originated in the NPS. A higher degree of resolution enabled the Japanese group to ascertain that the main contribution to the observed luminescence of the heated gas in the NPS was made by lines at 0.56 and 0.57 keV (oxygen with sixfold ionization) and 0.65 keV (oxygen with sevenfold ionization). Comparison of the observed results with calculations for the expansion of supernova remnants made it possible to deter-

mine the initial kinetic energy of the ejected gas (approximately 3×10^{51} ergs), the age of the remnant (approximately 10^5 years) and the concentration of the interstellar gas in the area of the explosion (approximately 10^{-2} cm^{-3}).

Thus X-ray observations have demonstrated that the NPS is the remnant of the explosion of some object. Is it possible, however, to affirm with such confidence that it was the explosion of a supernova which led to the formation of the NPS? At present such a categorical assertion would apparently be somewhat premature. The problem is that only the angular dimensions of the NPS have been measured directly, while in order to determine the fundamental characteristics of the explosion, for instance the initial energy of the ejected gas, it is necessary to know certain linear parameters, i.e. the actual distance to the NPS.



Results of spectral measurements by the Japanese group. On the left is the spectrum of the background radiation in a direction "past" the NPS; on the right is a spectrom or the radiation in the direction of the NPS. The solid curve is the approximate spectrum of background radiation. The points are observational data of the Japanese group. The ordinate gives the intensity of the X-rays and the abscissa the photon energy.

Key: a: Photons per square centimeter per second
b: keV [kiloelectron-volts]

The estimates given above were based on a distance to the explosion remnant determined by observing the polarization of the light of stars resulting from its scattering by interstellar dust. The idea behind this method of determining the distance is quite simple: when the dust particles are randomly oriented the overall effect disappears, but in a magnetic field the dust particles are predominantly oriented in such a way that light passing through an area in which they are present becomes partially polarized. If now the light of the farther off of two stars projected against the NPS is polarized and that of the closed is not it may be considered that we have determined an interval within which the distance to the object falls. The use of a large number of reference stars narrows this interval.

However, such a method may lead to an erroneous determination of the distance if, for example, the NPS is farther off but there is another area lying closer on the same line of sight where polarization of the starlight also takes place. Accordingly it is desirable to have an independent estimate of the distance, for example on the basis of absorption of X-rays in the interstellar gas. If two independent methods lead to results that are in agreement, the problem of

the NPS may be considered solved in its general outline. However, the situation is obscured by the fact that the distance determined through X-ray data is considerably larger than that obtained on the basis of optical observations. In any case, in the dependence on galactic width of the number of photons recorded, obtained by the Japanese group, there is a deep, narrow minimum in the direction precisely along the galactic plane. The apparent cause of this minimum is the absorption of X-rays by the interstellar gas, but in this case the NPS must be situated at a distance of several thousand parsecs.

Thus, two different methods of determining the distance lead to significantly diverging results. Which of them is closer to the truth will be shown by further observation and calculations. For the moment we can only say that is the distance to the NPS is larger it must be located in the central part of the galaxy, and its diameter may be as large as 10,000 parsecs. Only the explosion of a galactic nucleus could lead to the production of such a large object; in this case the kinetic energy of the ejected gas would initially (about 10 million years ago) have reached an immense magnitude: 10^{55} ergs.

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COSMONAUTS STUDY THE EARTH

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[Article by G. A. Ivanyan and K. Ya. Kondrat'yev]

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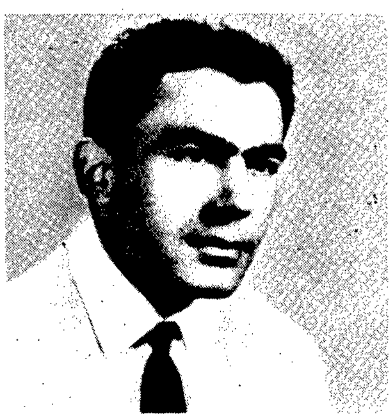
Kirill Yakovlevich Kondrat'yev [right] is a corresponding member of the USSR Academy of Sciences and heads the department of Atmospheric Physics at the same university. A specialist in atmospheric physics and space research, he has received gold medals from the World Meteorological Organization and the Royal Society, London. He is the author of a number of monographs and popular science books.



There is an extensive class of missions which can be effectively performed only by piloted space vehicles whose crews have been trained to carry out the requisite scientific program. The main advantage of piloted space vehicles is the possibility of immediate operational analysis of information on board, when the cosmonaut can choose among objects of study in the light of the natural situation and the set of equipment which is available on the spaceship. Only on piloted vehicles is it possible to change the program rapidly so as to study developments which appear on the earth's surface or in the atmosphere during the flight. In addition, such vehicles are the best suited to perform specialized research programs involving timely alerting of operating surfaces to dangerous phenomena and natural disasters, to conduct preliminary processing of information obtained, and finally to conduct visual observations (as a supplement to instrumental observation).

Numerous instances demonstrate that the conditions of space flight do not hinder creative activity on the part of cosmonauts. For example, it was only owing to the presenc of cosmonauts on board spaceships that it was possible to detect a number of new geophysical phenomena, in particular the vertically rayed structure of diurnal radiation in the upper atmosphere; the luminescence in the area of the southern geomagnetic pole, the photographic and spectral recording of which was performed in June 1975 by the crew of Salyut-4; the "whisker"effect: the existence of a luminescent layer on the nocturnal side of the earth; and the "specular" reflection of solar radiation by the atmosphere when the sun is low on the apparent horizon. Observation of the solar corona from space against the background of the luminescent layer of the earth's atmosphere near the twilight horizon directly before sunrise or after sunset was of great significance.

The essence of these phenomena can be understood by examining the diagram of the successively developing optical phenomena near the nocturnal and twilight horizons on the earth, drawn up on the basis of visual observations by G, T. Beregovoy, Ye. V. Khrunov and V. I. Sevast'yanov.When a spaceship is in the earth's shadow, before the sun rises a homogeneous luminescent ash-gray layer of constant thickness can be observed above the nocturnal horizon (between azimuthal angles of 80-280° from the direction toward the sun). The crew of the spaceship Soyuz-9 observed above the noctilucent ash-gray layer a narrow homogeneous bright layer in the form of a corona of grayish light with a pink tint at a constant distance from the earth's horizon. Above this fine luminous corona was the black sky. During his flight in the spaceship Soyuz-8, cosmonaut A. S. Yeliseyev was able to distinguish a fine layered structure in the luminous corona, consisting of several threadlike layers.

As the viewing angle decreased (in the present case, the angle of the sun beyond the horizon) the nocturnal corona persisted on the side of the horizon opposite the sun. In the vicinity of the "sunflower" point its thickness gradually increased, it became "shaggy" and began to wear away. When the angle of the sun behind the horizon reached a sertain size the luminous corona disappeared in the region of the sunflower point and the phenomenon of space glow, with the characteristic gamut of colors, appeared in this area. The luminous layer persisted to the left and right of the glow, but the sections of the corona adjoining it became shaggy and took on a vertically rayed structure: fine lumin-

filaments passing from the bright zone at the horizon to a height about twice as great as that of the luminescent corona. The upper boundary of the nocturnal layer, according to data from Soyuz-5 and Soyuz-9, was at an average height of 90 and 95 kilometers respectively. The vertically rayed structure was observable at azimuthal angles relative to the sun of up to 70-80 degrees.

The observations conducted by the cosmonauts became the foundation of the theory of the twilight halo of the earth.

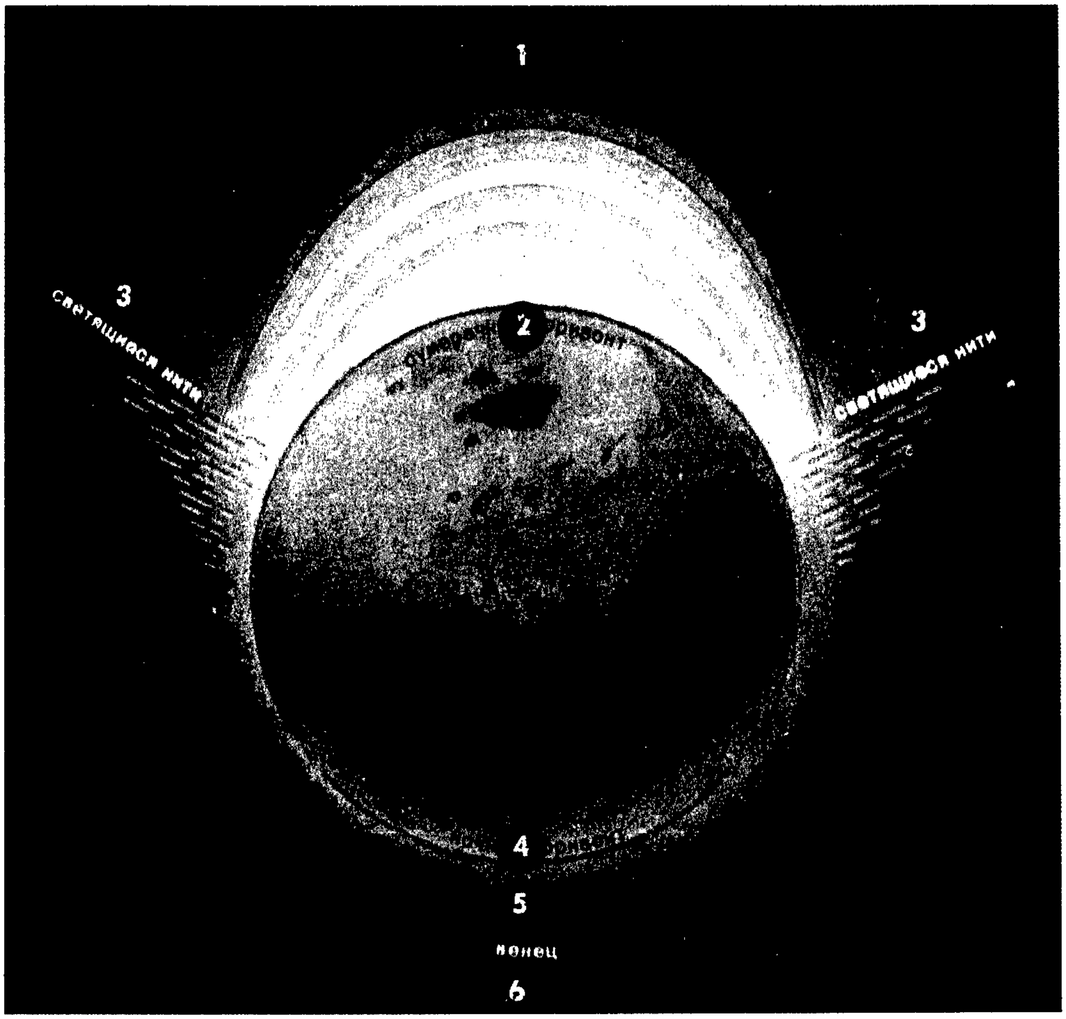
This is how cosmonauts A. G. Nikolayev and V. I. Sevast'yanov described the evolution of the light of the twilight halo in a vertical direction (according to observations made during the 18-day flight of Soyuz-9). As the sun rose, the glow initially had the appearance of a small dark red sickle. The sky then began to become clearer above the sickle, after which orange-red and yellow colors appeared along with the dark red. As the angle of the sun behind the horizon decreased, the dimensions of the twilight zone, occupied by the bright halo, increased. At the same time, the red tones in the halo became brighter and dark and light blue tones began to appear. The twilight halo had its maximum angular height (about 4 degrees with a spaceship orbital height of 230-240 kilometers) directly before the sunrise. At the moment when the first ray of sun appeared, the halo contracted, abruptly shrinking to about a third of its vertical dimension.

When the sun had already risen but the spaceship was still above the shadowed area and beyond the terminator, the central part of the zone which had been occupied by the halo lost its range of colors. The sun shone brightly against the dark background of space, but along the line to the terminator to the right and left of the sun could be observed the characteristic luminescence of the twilight halo in the form of "whiskers". When the sun was 6-15 degrees above the horizon, the halo seemed to break away from the earth's surface in the area of the terminator and moved off into the black starry sky in a strictly tangential direction, forming the characteristic zones of luminescence ("whiskers"), symmetrically situated relative to the sun, with a spectrum of colors in the vertical direction analogous to the spectrum in the expanded twilight halo. The "whiskers" disappeared at the moment when the spaceship crossed the terminator.

The observation of mesospheric (silver) clouds by cosmonauts V. I. Sevast'yanov and A. G. Nikolayev during the flight of Soyuz-9 must be considered one of the most interesting visual observations from space. On the Salyut-4 orbital station, V. I. Sevast'yanov and P. I. Klimuk succeeded not only in observing the silvery clouds but also in making spectrophotometric observations of them.

Many interesting ohenomena have been discovered from the records of cosmonauts' visual observations above the surfaces of the continents and oceans. Yu. A. Gagarin was the first to appreciate the great possibilities for visual observation from space in the study of the earth's surface and atmosphere. During his flight he could clearly distinguish from an altitude of 300 kilometers mountain ranges, major rivers, large forest areas, the shapes of islands, the forms of seacoasts, and clouds and their slight shadows. The water surface appeared darkish to him, although it glistened with spots. On the horizon Yu. A. Gagarin

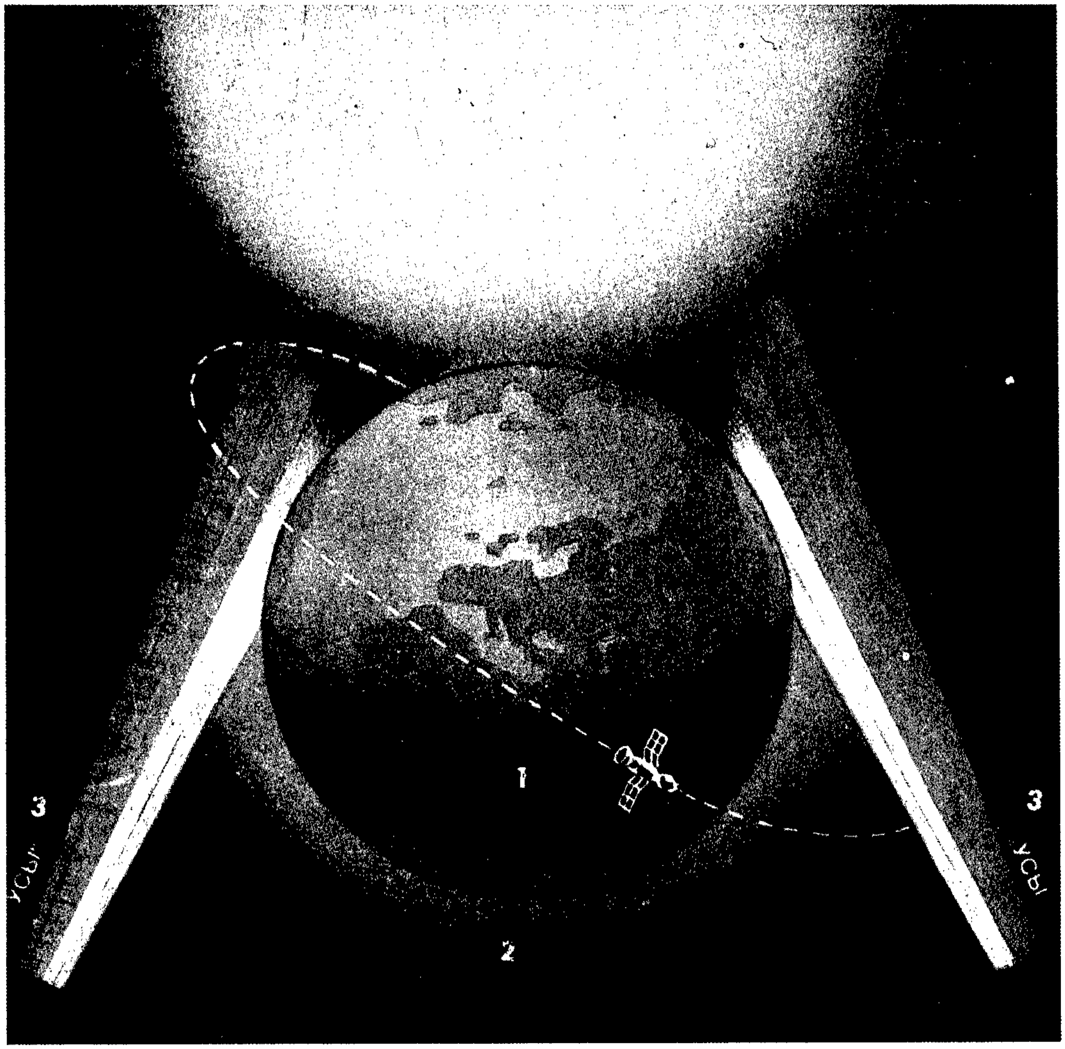
could see a sharply contrasted transition from the bright surface of the earth to the completely black sky. He saw surrounding the earth a halo of a delicate blue color which gradually darkened, becoming turquoise, dark blue, violet, and finally passing to a coal-black color.



Vertically rayed structure of light phenomena in the upper atmosphere of the earth, in the area of transition from the noctilucent corona to the zone of the developed twilight halo (from observations made from the Soyuz spaceships).

Key:
1. Twilight halo
2. Twilight horizon
3. Bright filaments
4. Nocturnal horizon
5. Luminescent layer
6. Corona

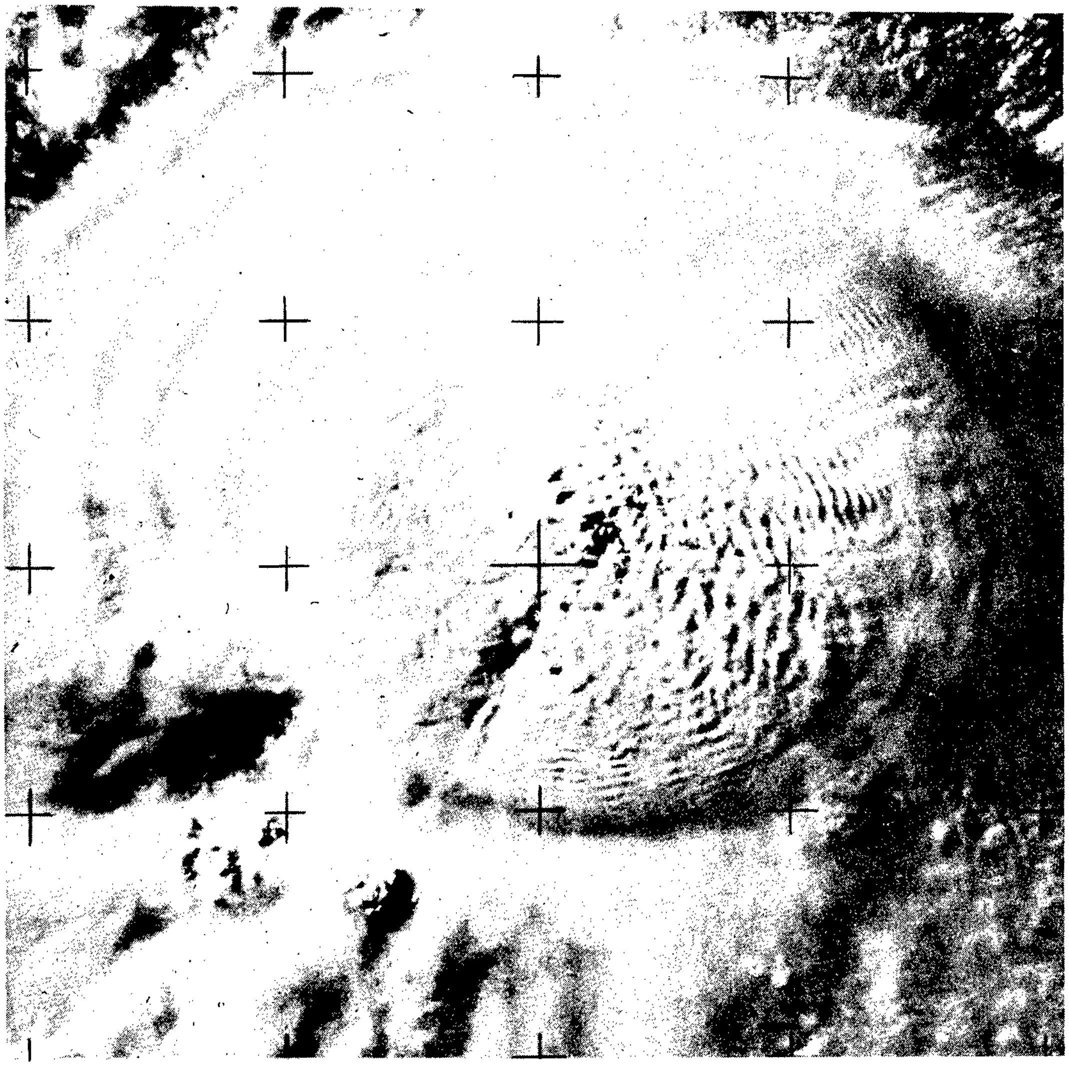
The great possibilities of space observation stem from the highly developed capacity of human vision to distinguish extremely fine variations in the color and brightness of various surfaces and atmospheric formations and to detect objects and follow their movements. From an altitude of 200-300 kilometers cosmonauts could distinguish ground objects of extremely slight dimensions and low contrast



Vertically rayed structure of light phenomena, noctilucent layer and "whisker" effect (from observations made from the Soyuz spaceships).

Key: 1. Area of shadow
2. Luminous layer
3. "Whiskers"

and identified extremely subtle color variations. From such a height, according to calculations, a man with normal visual acuity can see objects with a size of 200-300 meters. In practice, under especially favorable conditions, cosmonauts could distinguish objects with a size of a few tens of meters. Thus the American astronaut G. Cooper reports that he saw from space the launching pads of an American space center, the runways of airports, streets, and even smoke from the chimneys of houses. He even saw a truck moving along a highway near the U.S.-Mexican border. Another American astronaut, E. White, was able to see roads and motorboats on the surface of the sea from space. Cosmonaut G. T. Beregovoy was able to detect seagoing ships clearly by their wakes.



Tropical storm [Elin] over the North Atlantic in September 1973. The hurricane was born on September 19 [above; caption continues on following page].

During a number of flights cosmonauts observed ocean and sea water tints of various origins. According to data on such observations conducted from the Skylab orbital station, the existence of middle-sized outflows of hot subsurface waters was discovered in the ocean, as well as the meeting of blue ocean water and brownish influxes of river water.

In their observation of the earth, cosmonauts frequently saw a number of transient phenomena: forest and prairie fires, dust and sand storms, cyclones, gales, rainstorms, tides, thunderstorms and anthropogenous phenomena, i.e. things which frequently pass unnoted by automatic apparatus in space, since many of the phenomena would be scarcely detectable by instruments. In certain cases cyclones and gales were observed from piloted space vehicles earlier than by meteorological satellites. As the American astronaut H. Schmitt rightly noted, the eyes and brain of man are the best optical-computer discrimination system.

[caption continues from preceding page] The hurricane reached full development on 23 September [above]. The eye of the storm is clearly visible. The photographs were taken from the Skylab orbital station.

It is quite significant that in the planning of batteries of apparatus for the study of earth resources, for example in the creation of the EREP equipment for the Skylab station, the participation of cosmonauts in the experiments is now planned for. This makes the apparatus cheaper and more reliable.

The EREP instrumentation consisted of a multispectral photography unit, an IR spectrometer, a multispectral scanning unit, a superhigh frequency radiometer-scatterometer and an altimeter. Before beginning work, the crew checked the instruments, set up an earth observation camera in the scientific apparatus compartment, calibrated the sensors, filled the magazines of the photographic units with film, and selected the photographic and color-filter settings. When necessary the crew changed the components in the multispectral photographic apparatus, the cryogenic cooler and the detectors in the scanning unit. The astronauts themselves chose the subjects of research. If the areas previously designated for observation were covered by clouds, the astronauts were able to redirect the apparatus toward another objective. In addition, the crew members were able to react operationally to orders from the earth and to make their own decisions regarding photographing and observation of interesting phenomena and objectives on the earth's surface and in the atmosphere. The selection of objectives and of data to be recorded considerable increased the yield of useful information. Generally those observations which could be performed under the most favorable conditions, especially in the case of areas which had previously been studied, were made. The astronauts performad dozens of unplanned experiments; in particular the first Skylab crew conducted 7 such experiments and the second crew 13.

Complex atmospheric waves. The photograph was taken from the Skylab station.

Cosmonauts were assigned an important role in conducting Soviet experiments involving spectrographic measurements of the twilight horizon of the earth and the subjacest surface and atmosphere by the use of hand-held spectrographs of the RSS-1 (Soyuz-5), RSS-2 (Soyuz-7, Soyuz-9, Salyut-1, Soyuz-13, Salyut-3), and RSS-2M (Salyut-5) types and the KSS-2 battery of solar spectrometers (Salyut-4), which were constructed by the Physics Department of the Leningrad State University. To calibrate the RSS-2M against the sun for various settings and exposures, the cosmonaut had to perform more than 30 operations, while the conditions for performing the experiments were extremely harsh: in spectrographic measurement of the subjacent surface the deviation from the nadir could be no more than 10 degrees, and in spectrographic measurements on the sun the deviation of the slit from the center of the sun's disk could be no more than 5 degrees. Spectrographic measurements of the subjacent surface through polariod were conducted in such a way that the vertical line of the view-finder was oriented along the flight path; during photography of the earth horizon this line

ducted a number of special observations, which included the photographing of volcanic zones in Bolivia and Chile at the height of their activity; photographing the formation of the ice cover (from the beginning to the end of the process) in the St. Lawrence estuary; the photographing of cold eddies in areas of warm oceanic currents, with characteristic cloud formations serving as indicators; the photographing of cloud structures in the eye of a storm and the recording of agricultural crops in the initial phase of ripening. Among some of the other most interesting observations we may note the detection of icebergs in the South Atlantic; the photographing of characteristic cloud fields of cyclones and jet streams; the photographing of clouds arising as a result of advection of cold air above the warmer surface of the ocean; the detection of atmospheric and water pollution of various origins, sand dunes, ice and snow cover, solar "paths" and so forth. The crew's visual observations made possible a detailed study of color characteristics, texture and dynamics of agricultural lands and other anthropogenic land patterns in various areas of the globe. At the same time, the influence of the geometry of the land area, the illumination conditions, atmospheric haze and other factors, was also examined.

Thus the utilization of piloted space vehicles significantly expanded the possibilities for study of the environment and the natural resources of the earth. The presence of cosmonauts on board made possible not only the performance of such geospacial experiments as would be extremely difficult to perform on automated space vehicles, but also increased the experiments conducted. The participation of specialists--geographers, geologists, geophysicists, meteorologists, oceanologists and so forth--in flights as research cosmonauts makes possible an even greater increase in the effectiveness of geospace research.

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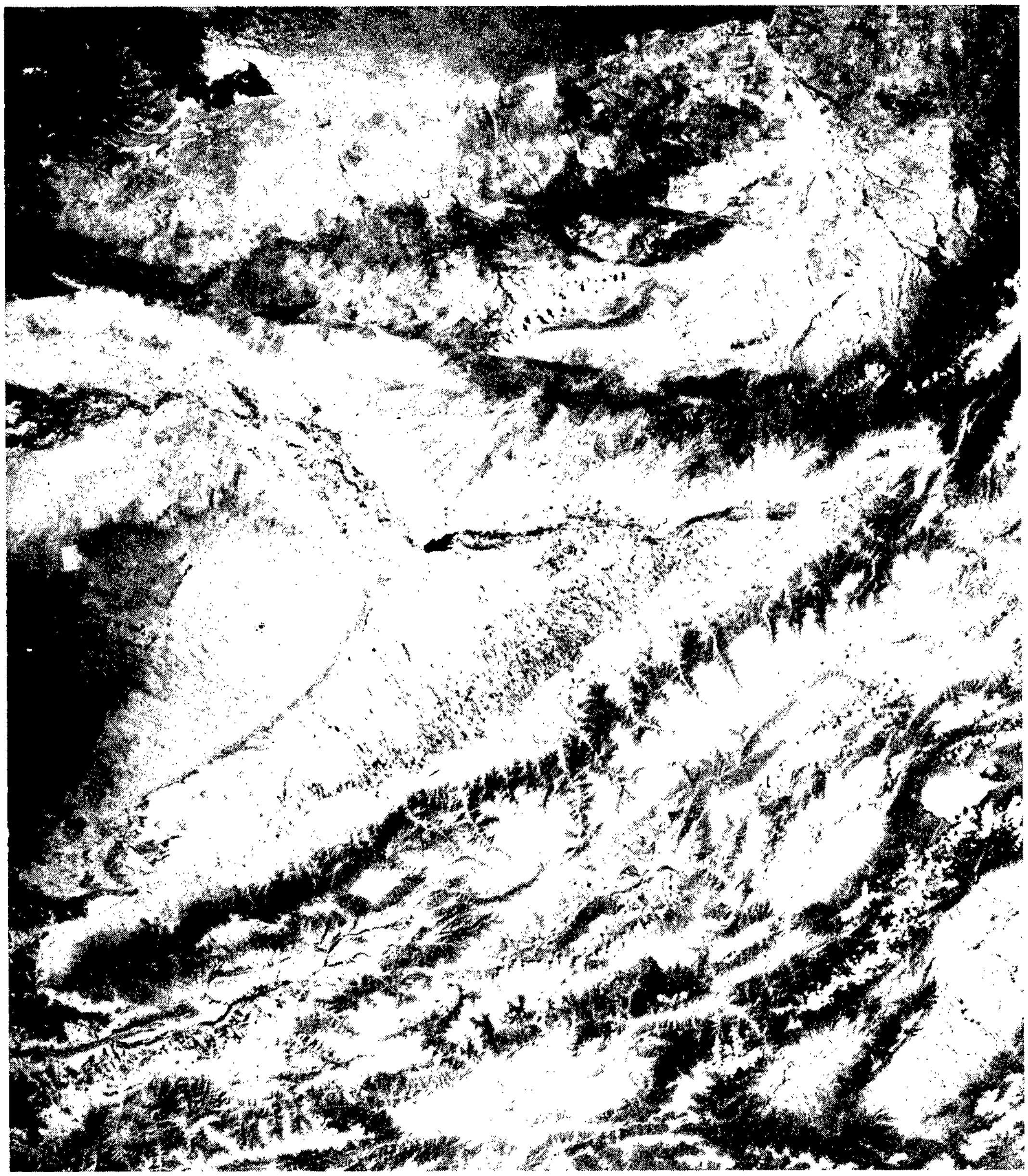

The northern Tyan'-Shan'. Large faults in the earth's crust, including the Talasso-Ferganskiy (above) and Dalair-Naymanskiy (below) faults, glaciers, depressions and ice-capped areas are clearly visible.

In their training they made use of space photographs on a scale of 1:2,500,000 which represented the earth in a manner very close to that which would be observed visually from a flight altitude of almost 280 kilometers. The cosmonauts had these pictures available during the flight. Some of the space photographs illustrate this article. They were taken during the flight of the Salyut-4 orbital scientific station.

The Crimean Peninsula. Fields, the mountains of the Crimea and their straight-line boundaries, which correspond to faults in subsurface layers, are clearly visible.

The visual experiment was conducted initially at the height of summer and then in the depth of winter, and accordingly it was possible to observe natural objectives in various conditions.

In the experimental program top priority was accorded to the observation of geological objectives. For example, the study of the Sevan fault, which extends along the northeast bank of Lake Sevan, was investigated. This fault has long

The northwest Caspian region. The shape of the Volga delta, the Caspian shoreline with traces of receding sea level, and the course and drift of rivers are visible.

Both crews performed a series of other interesting observations. For example, in South America, and especially with the rising sun at a low angle above the local horizon, it was possible to see clearly jungle areas that were submerged by river flooding. A dust storm covering an area of several hundred square kilometers was clearly visible in the Takla Makan desert. Numerous forest and grass fires were identified in Africa and South America.

The south shore of the Aral Sea and the delta of the Amudar'ya. Irrigated areas, the relief of sand deserts, and changes in the shoreline are clearly distinguishable.

Observation of environmental pollution was included in one section of the experimental program. A group of chimneys emitting smoke in the area of the city of Navoi, on the territory of the Soviet Union, was selected as one of the test objectives. Atmospheric pollution on a significant scale was noted by the cosmonauts in areas of countries in Africa and America where petroleum refineries were located. Gas flares above oil wells, for example, were clearly visible

SCIENTISTS AND SCIENTIFIC ORGANIZATIONS

KELDYSH DISCUSSES MERITS OF LENIN PRIZE WINNERS

/Moscow PRAVDA in Russian 22 Apr 78 p 8/

/Article by M. Keldysh, academician and chairman for Lenin and State Prizes of the USSR for Science and Technology: "In Unity with Practice."/

/Text/ The great Lenin's testamentary and indissoluble connection between science, practice and production is constantly the center of attention of the Party and the Soviet state. L. I. Brezhnev, secretary-general of the Central Committee of the CPSU and President of the Supreme Soviet of the USSR, emphasized the importance of this requirement in conversations with the party-economist aktiv in Novosibirsk oblast during his trip through Siberia and the Far East. He said, "We must press further ahead so that scientists will actively help us solve the problems of relating science to practice and, by so doing, will promote growth of the country's productive forces."

It is the joining of science and practice, which is in itself of great scientific significance, that characterizes work which has been favored by Lenin Prizes in 1978. This work is in various fields of science and technology and is of great importance to the economy and the development of science itself.

Algebraic concepts and processes are widely used in theoretical and applied mathematics and theoretical physics, and that is why the study of problems in this field is extremely urgent. The work in various fields of algebraic geometry of V. P. Platonov, academician at the BSSR /Academy of Sciences/ has enjoyed great notoriety here and abroad. His contribution is the solution of two monumental problems in the theory of algebraic groups: the theory of approximation and the so-called Tanak-Artin problem which surfaced more than 30 years ago. Their solution required the creation of fundamentally new methods which produced important results even in some related fields of mathematics such as algebraic geometry, number theory and the theory of groups.

For almost 20 years quantum electronics have revolutionized science and technology. The creation and development of a number of specialties in the physical sciences, such as laser spectroscopy, have resulted. V. S. Letokhov

diseases. Yu. A. Ovchinnikov and V. T. Ivanov decoded the structure and action processes of a new class of natural compounds, the ionophor which transports ions of one or another metal through the membrane, thereby basically influencing the active life of the cell. These studies are important to science, medicine, and the economy.

The works of academician N. V. Tsitsin in the theoretical bases of distant hybridization and formation of new valuable types, forms and strains of agricultural plants have great scientific and practical significance. He identified the process mechanism for developing new plant forms and deriving distant hybrids. He proposed schemes for crossing and selection which make possible the creation of new stable forms of agricultural cultures that have desirable properties and characteristics. This scientist developed, for the first time in the world, rye-agropyrons, other distant hybrids and new varieties of soft wheat. He obtained perennial feed-grain wheat, tetra ploid feed rye and winter wheat-agropyron hybrids with a yield of 70 centners per hectare. A variety of spring wheat, "Grekum-114", a tetra ploid winter rye "Start", and a feed-grain wheat "Otrastayushchaya-38" have been regionalized.

Lenin Prizes have been awarded to works in the field of technology.

M. G. Pantyukhin, A. M. Dobrynin and others developed a family of standardized wheeled tractors, "Kirobets", which with various modifications are used in agriculture, forestry, road building and construction. These tractors are maneuverable, durable, handy, and reliable.

The creation of the largest optical telescope in the world is a great achievement for Soviet science and technology. It is of fundamentally new construction and has a main mirror with a diameter of 6 meters. This became possible thanks to the high scientific and industrial potential of the country. This unique astronomical instrument was created by a large collective of specialists which included M. P. Panfilov, V. A. Zverev and others. The chief designer of the telescope, B. K. Ioanisiani, had been awarded the Lenin Prize earlier.

The telescope was designed for observation of the weakest and furthest cosmic objects. Its introduction on line has opened new possibilities for solving a number of key problems concerning the conceptions of the formation and evolution of the universe, and the realization of programs of most important astrophysics research.

Important achievements in medicine have also earned Lenin Prizes.

Laser and ultrasonic microsurgery of the eye, under the leadership of academician M. M. Krasnov, USSR Academy of Medical Sciences, has played a great role in the development of scientific and practical ophthalmology. For the first time in world medical practice new highly effective methods for treating serious diseases of the eye, such as glaucoma, cataracts and

SCIENTISTS AND SCIENTIFIC ORGANIZATIONS

ACHIEVEMENTS AND PLANS OF FAR EASTERN SCIENTIFIC CENTER DISCUSSED

Moscow IZVESTIYA in Russian 30 Apr 78 p 2

[Article by N. Shilo, Academician and President of the Presidium of the Far Eastern Scientific Center: "Pacific Ocean Outpost of Science"]

[Excerpts] Exceptionally important significance for the fulfillment of the decisions of the 25th CPSU Congress for the comprehensive assimilation of the natural resources and development of the production forces of Siberia and the Far East is attached to Comrade L. I. Brezhnev's trip to these regions and his instructions and recommendations, which touch on fundamental issues of the economy and scientific and technical progress and draw attention to reserves.

The scientific potential of the Far East is one of these reserves. As is well-known, in 1970 a scientific center was created in Vladivostok which has developed into a major complex of the Academy of Sciences. It consists of 16 institutes and a large network of stations and reserves. Research of importance to the national economy is underway in many of our subdivisions. For instance, research into problems of the geology of noble metals, tin, tungsten and boron and their chemical processing; questions of the exploitation and reproduction of biological resources; the use of geothermal energy; the prediction of volcanic activity and earthquakes; the physics of the seas and oceans; and the mineral and raw material resources of the continental shelf. A large role is assigned to the study of processes of control, particularly important for the Far Eastern complex with its enormous territory. The ionosphere and magnetosphere are being comprehensively studied.

Our most developed sciences are the earth sciences, with which almost half our institutes are concerned. These include the geological, oceanological and geographical institutes in Vladivostok; the Northeastern complex Institute in Magadan; the Institute of Techtonics and Geophysics in Khabarovski; the Institute of Volcanology in Petropavlovsk-Kamchatskiy, and the Sakhalin Complex Institute in the settlement of Novoaleksandrovsk. Their collectives are studying the structure, composition and processes taking place in the earth's crust and mantle in the Pacific and the land which surrounds it. A

It would seem that the highly theoretical Institute of Tectonics and Geophysics is having a noticeable influence on the applied geological study of the region through the organizations of the USSR Ministry of Geology. The Institute of Marine Biology has strong business ties with the Pacific Ocean Scientific Research Institute of Fisheries and Oceanography and the "Dal'ryba" Association. The Pacific Institute of Bio-Organic Chemistry has prepared suggestions for the development of a number of biochemical production facilities in the Far East. The collective of the Institute of Automation and Control Processes has carried out many research operations into mathematical methods of diagnosing technical devices and natural resources. And our youngest institute, the Economic Research Institute, has embarked on the study of problems connected with the construction of the Baykal-Amur Railroad and the economy of the World Ocean.

Unfortunately some scientific collectives formerly only seldom issued specific recommendations to the party, soviet and economic organs of the Far East and in a number of institutes some scientific salients lagged behind and miscalculations were allowed in introducing scientific research developments. The experience accumulated by the USSR Academy of Sciences Siberian Department with respect to links between science and production was not adequately used.

We have major work to do on increasing the efficiency of scientific research, reducing the time taken to introduce finished work into the national economy, and training and educating our scientific cadres in a spirit of high responsibility for the matter in hand.

At the same time it is essential to accelerate the construction of a number of institutes. Unfortunately, the large funds earmarked for the construction of laboratory buildings and apartment houses are not being assimilated. We hope the USSR Ministry of Construction of Heavy Industrial Enterprises, "Glavvladivostokstroy" and other departments constructing our projects will put the situation right. The problem of the creation of experimental bases and our own experimental production facilities and design bureaus, where it would be possible to develop the methodology and technology for the introduction of the results of research into practice, also requires the speediest solution.

Having attentively studied Comrade L. I. Brezhnev's instructions and recommendations, the scientists of the Far East Center have embarked on their implementation in a businesslike manner. At a recent Presidium session we discussed in detail the prospects for further scientific research into the comprehensive development of natural resources. The substantiation of fundamental directions of the development of the Far East production resources was also examined bearing in mind the construction of the Baykal-Amur Railroad over the period 1990 through 2000. For the successful solution of the tasks set by the party Central Committee, the CPSU Central Committee Politburo and Comrade L. I. Brezhnev personally we intend to

INCREASING THE EFFECTIVENESS OF SCIENTIFIC RESEARCH

Tallin SOVETSKAYA ESTONIYA in Russian 30 Mar 78 p 3

[Text] From the annual meeting of the Estonian Academy of Sciences SSR.

The scientists of Soviet Estonia marked the anniversary of the Great October Revolution and the adoption of the new constitution of the USSR by an increase in political and creative activity. The realization of the socialist responsibilities accepted by the collective of the Estonian Academy of Sciences had, in part, a million and a half ruble economic effect on the national economy of the republic.

The president of the Estonian Academy of Sciences, K. Rebane, at the opening of the 32nd annual meeting of the Academy, spoke about the accomplishments of Estonian science in 1977. The work of the many scientists of the republic has been positively evaluated in the annual report of the USSR Academy of Sciences. Several scientists of the Academy are worthy of the Soviet Estonia Prize. Among them are Ch. Villimann, O. Avaste, U. Veysman, and K. Eerme from the Institute of Astrophysics and Atmospheric Physics, as well as the pilots-cosmonauts of the USSR, G. Grechko, A. Gubarev, P. Klimuk, V. Sevastyanov. The collective was rewarded for the results of studying silver clouds in outer space with the aid of the teleradiometer "Mikron" which was built at the institute. The authors of excellent works such as "The History of the Estonian SSR" and the "Estonian Soviet Encyclopedia" are also deserving of the prize. The monograph of I. Saata and K. Siylivaska, "The Great October Socialist REvolution in Estonia" as well as a series of other works in the field of social science have been published.

Co-workers at the Institute of Economics have developed, at the request of the republic's government, the scientific bases of a long range plan for the devleopment and distribution of output in production, in agriculture, in everyday services and in construction. The plan should result in a more effective use of product and labor resources.

Chemists have achieved significant successes in the field of ultra-pure substance synthesis, in the introduction of protective measures in plants and in the development of insecticides. The fundamental data have been worked out for the construction of a perfume shop at the Maardyskiy chemical plant.

The annual meeting confirmed the report of the Presidium on the activity of the Estonian Academy of Sciences in 1977 and approved the plan for research and experimental work for the current year. The corresponding resolution was accepted.

L. Yurgenson, professor at the Tallin Polytechnical Institute, was elected Academician of the Estonian Academy of Sciences in the field of construction mechanics. K. Paaver, director of the Institute of Zoology and Botany, was elected Academician of the Estonian Academy of Sciences in the field of biology. Yu. Kakhk, academician-secretary of the Social Science Department of the Estonian Academy of Sciences, was elected Academician of the Estonian Academy of Sciences in the field of USSR history. P. Pal'm, professor at Tartu University, was elected Corresponding-Member of the Estonian Academy of Sciences in the field of chemistry.

The Estonian Academy of Sciences Prize for the best student scientific work for 1977 was awarded to I. Rayg, who graduated last year from the Estonian Agricultural Academy.

A. Vader, chairman of the Presidium of the Supreme Soviet of the Estonian SSSR; V. Vyalyas, secretary of the Central Committee of the Estonian Communist Party; E. Grechkina, department head of the Central Committee of the Estonian Communist Party; I. Nuut and V. Ryatsep, ministers of the Estonian SSR and A Kullaste, secretary of the Tallin City Party Committee took part in the work of the meeting.

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5. Nikolay Vasil'yevich Tsitsin, academician, director of the Main Botanical Garden of the USSR AS for a series of studies on development of theoretical bases of remote hybridization and the creation of new valuable species, forms and varieties of agricultural plants.

6. Gavriil Abramovich Ilizarov, doctor of medical sciences, director of the Kurgan Scientific Research Institute of Experimental and Clinical Orthopedy and Traumatology; Otari Naskidovich Gudushauri, academician of the GSSR AS, head of a Chair of the Tbilisi State Medical Institute for a series of studies on the development of a new method of treatment of patients with injuries and diseases of the skeletal motor apparatus and the introduction of this method into wide-scale practice in public health and the development of a new scientific and practical trend in traumatology and orthopedy.

7. Mikhail Mikhailovich Krasnov, active member of the USSR Academy of Medical Sciences, director of the All-Union Scientific Research Institute of Eye Diseases for a complex of investigations and the development of new principles of eye surgery.

8. Mikhail Grigor'yevich, deputy chief designing engineer, director of a study; Leonid Petrovich Pinchuk, director of tractor production; Yuriy Alekseyevich Sobolev, chief engineer, Mikhail Vasil'yevich Mashkin, shop superintendent and workers of the industrial association of "Kirov Plants", Anatoliy Mikhaylovich Dobrynin, general director of the Yaroslov Union for production of diesel engine automobiles; Georgiy Dmitriyevich Chernyshev, doctor of technical sciences, chief designing engineer of the same union, for development and creation of unified, power wheeled tractors "Kirovets" and mastery of series production of a basic modification.

9. Mikhail Panfilovich Panfilov, general director; Vicktor Alekseyevich Zverev, candidate of technical sciences, chief engineer of TsKB [Central Design Office]; Yefim Meyerovich Neplokhov, candidate of technical sciences, chief of laboratories, Vladimir Aleksandrovich Kovalev and Vasiliy Nikolayevich Pavlov, leading designing engineers, workers of the Leningrad Optical Mechanical Union imeni V. I. Lenin for development of the world's largest telescope of a new (in principle) design with a main mirror of 6 meters in diameter.

10. Aleksandr Semonovich Tager, doctor of technical sciences; Viktor Mikhaylovich Val'd-Tserlov, candidate of physicomathematical sciences; Anatoliy Ivanovich Mel'nikov, candidate of technical sciences, head of laboratories; Yuras Karlovich Pozhel, academician of the Academy of Sciences of the Lithuanian SSR, director of the Institute of the Physics of Semi-conductors of the LISSR Academy of Sciences for a complex of theoretical and experimental studies of the generation and amplification of super-high frequency electromagnetic vibrations during cascade ionization in semi-conductions and the creation of a new class of semiconductor apparatus-cascade-transit diodes.

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